Medical Treatment Facility Pollution Prevention Guide

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CHAPTER 1 - INTRODUCTION

1.1 OVERVIEW

The current emphasis on pollution prevention (P2) is necessary to meet State and National pollution prevention policy goals, protect public health and the environment, save money by reducing the medical treatment facility's (MTF's) raw material purchases and waste disposal costs, and reduce the long-term liabilities associated with waste disposal.

Environmental liabilities increase directly with the volume of hazardous substances used at an MTF. Reducing long-term liabilities requires a dedicated commitment, a sound plan, and an aggressive effort for modifying past attitudes toward the conservation of all materials. Reducing liabilities also requires actively searching for opportunities to reduce the amount of hazardous substances used and pollution generated while still accomplishing the MTF's mission.

Pollution prevention can be a cost-effective method of reducing these liabilities and meeting environmental objectives in an era when military MTFs are simultaneously subject to stricter standards for pollution control and declining budgets.

1.2 PURPOSE

This guide was developed to identify P2 initiatives for MTFs, in order to ensure environmental compliance with Federal and State pollution prevention laws and regulations as well as Department of Defense (DOD) policy. This document is a multimedia guide that provides information on various types of pollution generated and resources used. The purpose of this guide is to identify P2 opportunities that exist at MTFs, and to serve as a technical reference for implementing future P2 initiatives.

1.3 SCOPE

Pollution prevention has often focused primarily on hazardous waste (HW) reduction. However, as a multimedia document, the scope of this Medical Treatment Facility Pollution Prevention Guide extends beyond HW reduction issues to include a wide range of environmental media such as solid waste reduction and recycling, regulated medical waste reduction and disposal options, and affirmative procurement. This guide focuses on identifying P2 initiatives for implementation by MTF activities that will have the greatest impact on waste reduction and resource conservation. This guide is intended for use by MTFs throughout the Army, and in particular by their administrators and environmental compliance personnel.

1.4 FORMAT

For all potential P2 initiatives identified for the areas of Hazardous Waste, Regulated Medical Waste, Solid Waste, Air Pollution, Universal Wastes, and Hazardous Material Management, this guide provides a general description of the initiative, as well as environmental, technical, and economical considerations, where appropriate, based on assumptions made from manufacturers' information, historical data, process knowledge, and engineering judgment. Sample calculations are provided to show how the data can be used to determine each initiative's cost saving potential for MTFs of varying sizes, and are presented as an example only of how to determine the specific cost effectiveness for your specific facility. The individual MTF may then use these analyses as a basis for initially evaluating the initiatives at its own facility by inserting their actual data. Any vendors and service providers listed in this report are for general comparison purposes only, and may serve as useful leads for further investigation. Use of trade names in this guide does not imply endorsement by U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), Department of the Army (DA) or DOD but is intended only to assist in identification of a specific product.

CHAPTER 2 - HAZARDOUS WASTE

2.1 DESCRIPTION

While the volumes of HWs generated are small in comparison to an industrial facility, MTFs do employ a wide variety of toxic chemicals and hazardous materials for numerous diagnostic and treatment purposes.

Depending on the size of, and services available at the individual MTF, most, if not all of the following HW generating processes are present: X-ray film photo processing in various departments (e.g., radiology, mammography, dental clinics, and veterinary clinics); equipment sterilization, pathology and histology laboratory sample preservation and testing; and certain expired pharmaceuticals at the pharmacy. Additionally, many types of fluorescent light bulbs and batteries used throughout the MTF, when discarded or no longer serviceable, become an HW, as does mercury-containing equipment when they break or become obsolete (e.g., thermometers, blood pressure monitors (sphygmomanometers), and esophageal dilators).

2.2 CATEGORIES OF WASTES

2.2.1 X-Ray Film Processing

2.2.1.1 Waste Generated – Spent X-Ray Fixer and Rinse Water

Conventional methods of developing X-ray film use a large volume of chemicals (developer, fixer, and rinse water). Fixer solutions remove silver compounds from the film during the photo developing process. The fixer is "spent" or "used" after it has been contaminated with silver (from processing X-ray films), often containing between 1,500 and 4,000 parts per million (ppm). The Resource Conservation and Recovery Act (RCRA) characterizes wastes with silver concentrations above 5 ppm as hazardous, which may require certain waste management practices.

The rinse water, which is used to wash excess fixer off of the X-ray film, may commingle with some of the fixer solution and therefore could contain silver in concentrations above the regulatory limit. This rinse water must also be considered when deciding on a P2 initiative that might be implemented. The two basic P2 opportunities associated with X-ray processing are onsite silver recovery and digital X-ray imaging.

2.2.1.1.1 Potential P2 Initiative – Onsite Silver Recovery System

a. Description. Silver recovery systems separate and collect the silver from the used fixer, and, if necessary the system's rinse water, which can result in the elimination of a waste stream, and reduce HW disposal costs. Silver recovery can also provide revenue from precious metal recovery. For the purposes of this analysis we shall assume that 400 gallons of this waste are generated each year and that the silver concentration is 2,000 ppm.

b. Technical Considerations. Silver recovery units operate with various technologies or electrochemical processes; however, their common function is to separate and collect the silver ions from the used fixer solution. These silver recovery units should be turned in to the local Defense Reutilization and Marketing Office (DRMO) in order to support the DOD's precious metals recovery program as described in DOD 4160.21-M, Chapter 11, although use of contract services is considered an adequate alternative. Silver recovery is required/mandatory by Army Regulation (AR) 40-61 (Medical Logistics Policies and Procedures), because of its environmental and economic benefits. When silver is recovered and is subject to proper management, the costs for HW disposal are reduced and revenues are generated because the metal is recovered. Three of the most popular types of silver recovery technologies include: metallic replacement cells (MRCs), ion exchange (IX) columns, and electrolytic recovery (ER) units.

Metallic Replacement Cell - An MRC consists of a 3 to 5 gallon bucket which houses a core made of either packed iron fibers (like steel wool) or a tightly wound iron mesh. As the fixer and rinse water passes over the core, the iron replaces the silver in the fixer. The silver is integrated into the core's matrix while the iron and de-silvered fixer exit the cell. The longer the contact time, the more silver will be removed. As a result, activities that generate large amounts of fixer use multiple cells in series to increase the contact time. MRCs can be a cost-effective silver recovery tool, however, they are not generally adequate for meeting environmental standards (silver concentration below 5 ppm) as a stand-alone device for medium to large volume processing activities.

Advantages to MRC recovery include the simplicity of installation, low initial cost (a single MRC costs approximately $90), and low operating costs (replacement filters are approximately $50). Additionally, this equipment takes up very little room. For the X-ray processing units that generate small volumes of spent fixer, the use of the MRC alone (or a series of two) may be enough to remove the silver to below environmental standards for a minimum cost, providing adequate contact time is maintained.

The major disadvantages are the degree of maintenance and attention required to ensure that adequate contact time is provided to achieve a 5 ppm or lower silver content in the effluent, and the fact that recovered silver requires refinement resulting in a lower return of revenue for the sale of the silver. In general, one (or a series of two) MRC can be expected to process as much as 500 gallons of silver-bearing waste at a 2,000 ppm concentration and render an effluent of less than 100 ppm, but flow rates must be low enough to allow adequate contact time.

Ion Exchange - IX technology recovers silver by passing the fixer and rinse water through a column of synthetic resin. Active chemical groups in the resin allow for an exchange of ions between the resin and the fixer and rinse water solutions, causing the silver to adhere to the resin's surface. The resin is sent to a silver refiner for silver recovery.

The major advantage to IX is that it can consistently and reliably reduce silver concentrations to below 5 ppm with less maintenance. Additionally, IX is ideal for treating the volume and concentration of silver associated with rinse water.
The drawbacks include high initial cost and the technology can only handle solutions with a relatively low initial silver concentration (20 to 500 ppm). Therefore, it would not be suitable as a stand-alone recovery technology for most X-ray processing activities. The unit would most likely be placed after a primary recovery system such as the MRC mentioned above, in order to decrease the silver concentration of incoming effluent. The cost per IX unit is approximately $1,000. One IX column can be expected to process as much as 500 gallons of spent fixer solution at a concentration of 100 ppm.

Electrolytic Recovery - ER removes silver from used fixer and rinse water by suspending one cathode and one anode into the solutions and passing an electric current between them, causing the silver to plate onto the cathode.

One of the largest advantages to this technology is that it does not introduce any contaminants into the fixer solution, allowing it to be recycled back into the film development process. To recycle the fixer, however, a continuously recirculating unit (rather than a batch-mode unit) must be used to maintain a consistent fixer composition. The ability to recirculate the processed fixer is a major advantage since it can reduce the amount of new fixer procurement by approximately 75%. New fixer would still need to be added to replace that lost to evaporation, drag-out, and carry-over into the rinse water. Another advantage to ER is that the silver, which plates onto the cathode, is pure enough (90-98%) to be marketable without further refinement. The silver recovered from electrolytic units can be very economically profitable.

The major drawback to this technology is that fixer processed through an ER unit may still have a silver concentration in the 50 to 500 ppm range. Although this is much less than the initial concentration of 1,500 to 4,000 ppm, it is still well above the 5 ppm regulatory limit. A common practice to create an effluent with a silver concentration lower than 5 ppm is to utilize this system in conjunction with one of the above technologies. Electrolytic recovery is often chosen as the primary silver recovery system, followed by an MRC or IX column. For larger facilities, combining these technologies is an excellent way to take advantage of the strengths of each technology while also overcoming their individual deficiencies. The ER unit can cost approximately $3,000. The cathode cartridge must be replaced approximately every year.

If multiple X-ray processing units exist at various locations on an installation, it may be more economical for one silver recovery unit to be implemented where the effluents can be combined and processed. The size of the silver recovery system will be based on the number of gallons of spent fixer and rinse water that is created.

While the silver recovery units themselves won't require much room for use with systems processing larger amounts of spent fixer, a temporary storage tank for the spent fixer before it enters the silver recovery system may be necessary. Depending on the size of the operation, especially if combining spent fixer from several X-ray processing units, this tank could be quite large (50 to 150 gallons).

For compliance purposes, special attention should be given to sampling requirements (frequency and location) that may be imposed by State and local regulators. Discharge of rinse waters from the X-ray process should also be considered with regard to testing.

The installation and maintenance issues regarding silver recovery systems are usually fairly straightforward, requiring only simple plumbing and electrical connections.

c. Environmental Evaluation. This P2 initiative can reduce silver concentrations to below 5 ppm in used photographic fixer and X-ray fixer. This eliminates the need to dispose of used fixer as an HW and reclaims silver for resale as a precious metal. For this example, this initiative has the potential to remove an estimated 400 gallons, or 3,000 lb (400 gal x 8.34 lb/gal x 0.90 spec. gravity of the fixer) of silver-bearing spent fixer from the MTF's annual HW generation total.

d. Economic Evaluation. For this example, the following assumptions about the current management of the spent fixer are made:

- All spent fixer is being disposed of as an HW at a cost of $1.25/lb.
- There are no current agreements in place for recycling the spent fixer with an offsite contractor.
- All spent fixer is combined at one collection point (combining spent fixer from several generating activities will cut down on cost of running and maintaining several recovery units).
- 400 gallons of this waste are generated each year and that the silver concentration is 2,000 ppm (equal to 2,000 mg/L).
- This waste will be processed through a series of silver recovery devices. The first device in the series should be an MRC that is capable of handling high concentration levels and yields low quality silver. The second should be an IX column in order to render the waste essentially free of silver (<5 ppm).

i. <u>Implementation Costs</u>. Implementation costs would be incurred from the initial purchase of the silver recovery equipment, from the purchase of the gear to set it up, and the labor to perform the installation.

> *Silver Recovery Equipment*: One MRC unit ($90/unit) and one IX column ($1,000/unit), for a total of $1,090.
>
> *Equipment Set Up*: Includes tubing, hoses, containers, and pipes: $200
>
> *Time/Labor*: Assume installation of the combined system requires 4 hours, at a cost of $25/hr. Total cost for labor is $100 (4 hr x $25/hr).

Total Implementation Costs: $1,090 + $200 + $100 = $1,390

ii. Recurring Costs. Recurring costs would be incurred from the annual replacement of the silver recovery equipment, labor to perform the replacement, and testing of the effluent to ensure regulatory compliance.

Replacement MRC Filter: \$50/filter x 1 filter/yr = \$50/yr
Replacement IX Column: \$1,000/unit x 1 unit/yr = \$1,000/yr
Labor: 1 man-hour at \$25/hr = \$25/yr
Effluent Testing: \$20/quarter x 4 quarters/yr = \$80/yr
(Note, only needed once per year after baseline established - \$20/yr)

Total Recurring Costs: \$50/yr + \$1,000/yr + \$25/yr +\$80/yr = \$1,155/yr

iii. Recurring Cost Savings. Recurring cost savings would be realized from no longer having to pay to dispose of the spent fixer as an HW, as well as from any revenue received from the recovered silver.

HW Disposal Cost Avoidance: 3,000 lb/yr x \$1.25/lb = \$3,750/yr

Precious Metal (silver) Recovery: The silver credit is calculated by multiplying the concentration of the silver (lb/gal) by the annual volume of spent fixer (gal) by the market price for silver (\$/lb).

Silver Concentration:
2,000 mg/L x 1 kg/10^6mg x 2.205 lb/kg x 3.78 L/gal = 0.0167 lb/gal
Annual Volume of Spent Fixer: 400 gal/yr
Price of Silver: \$4.49/troy oz. x 1 troy oz./0.06857 lb = \$65/lb
Silver Credit: 0.0167 lb/gal x 400 gal/yr x \$65/lb = \$434/yr

Total Recurring Cost Savings: \$3,750/yr + \$434/yr = \$4,184/yr

iv. Payback Period. The payback for this initiative is calculated by dividing the implementation costs by the difference between the recurring costs and the recurring cost savings.

$$\frac{\$1{,}390}{(\$4{,}184/\text{yr} - \$1{,}155/\text{yr})} = 0.5 \text{ yr}$$

This example assumes that the MTF performs the silver recovery by itself, purchasing and maintaining the equipment, as well as gaining the financial benefit from the recovery and sale of the silver. As can be seen, as the amount of fixer being recovered increases, the payback period decreases. This allows the MTF to quickly break even and/or turn a profit from the system. Note the annual expenses of running the X-ray equipment (e.g., purchase of new fixer, developer, and film) are not included in the calculations, as this P2 initiative does not affect the amount of these items used. These materials would be expended at the same rate regardless if the spent fixer is reclaimed or disposed of as an HW. Ideally, any profit from the sale of the silver could be used to supplement the operating costs of the equipment. If the spent fixer can be combined at one central location and processed through one silver recovery unit, the silver recovery return would be maximized, as there would not be as many individual silver recovery systems to purchase and maintain.

Another popular alternative that would limit the MTF's implementation costs would be to establish a contract with a company to maintain the equipment and recover the silver. Depending on how the contract is set up, the contractor may provide and maintain all silver recovery equipment, and the installation will get a percentage of the money for the recovered silver, with this revenue either paying for all or most of the contract. Another option is the local DRMO may provide the silver recovery equipment, keeping all revenue from the recovery of the silver. In all cases, the MTF no longer has the spent fixer to dispose of as an HW.

Results may vary for each MTF, so it is important to use information pertaining to the MTF's unique situation when evaluating the useful potential of this initiative.

2.2.1.1.2 Potential P2 Initiative – Digital X-Ray Imaging

a. Description. Digital X-ray imaging or Computed Radiography (CR) provides an alternative to traditional film-based imaging; eliminating the need for chemical processing altogether. Computed Radiography uses phosphor screens rather than film to capture X-ray images.

These screens, which are highly sensitive to ionizing radiation, are able to trap and store the X-rays' energy. To retrieve the image, the plate must then be placed into a reader that scans it with a laser, releasing the stored energy as light. The reader then converts the light into a digital signal that can be saved to a computer's memory, sent to a monitor for viewing, and/or sent to a printing device to produce a hard copy. The phosphor screens, which may be used repeatedly, are available in the same sizes as traditional film grids and can be used with the same equipment and with the same X-ray exposure time as traditional film.

Before purchasing CR equipment, it is important to determine how this technology will fit into the facility's overall diagnostic imaging system. An emerging trend is for facilities to incorporate all of their imaging instrumentation (e.g., fluoroscopy, angiography, computed axial tomography, and magnetic resonance) into one electronic network. Under such networks, the images are recorded and stored in a standard electronic format rather than in hard copy. However, hard copies of any image can be generated using printers designed especially for producing medical diagnostic images.

Procuring and installing a CR system (consisting of a CR scanner, several phosphor screens, and a computer system with software capable of collecting and storing the electronic images) will cost anywhere from $250,000 to $1,000,000. The cost will depend mostly on the size of the MTF and the number of X-ray images it generates.

By utilizing CR, the MTF would avoid annual procurement costs for fixer and developer, and disposal costs for the fixer (assuming it is not currently being run through a silver recovery unit). The cost of X-ray film is comparable to the cost of the paper used to print the images from the CR, so these costs will cancel each other out and do not have to be considered.

b. Technical Evaluation. Several types of systems are now available, ranging from the standard body X-ray type system to systems specific for mammography, dentistry, and cardiology. Separate systems would have to be purchased to replace each individual X-ray system.

CR technology allows for immediate X-ray preview, and ease of viewing, transmitting, storage, and printing of the X-ray image. The CR system will fit in current X-ray rooms. A combination upright chest unit and horizontal table unit can be used to replace two separate chest and table units, thus saving space. The ability to store the images digitally will save on storage space used for traditional X-ray films.

c. Environmental Evaluation. As technology has improved, the application of CR is comparable to traditional radiography, and in certain aspects has exceeded it. By utilizing CR the MTF would eliminate the need for fixer and developer, thus avoiding having to dispose of these waste streams. Using the CR would also eliminate the developed X-ray films, which additionally contain some silver. The CR does not generate any HW.

Depending on the size of the X-ray system being replaced, the volume of fixer and developer no longer required each year would vary.

d. Economic Evaluation. For this example, the following assumptions about the X-ray imaging systems are made:

- All spent fixer is being disposed of as an HW at a cost of $1.25/lb.
- There are no current agreements in place for recycling the spent fixer with an offsite contractor.
- 1,000 gallons, or 7,506 lb (1,000 gal x 8.34 lb/gal x 0.90) of spent fixer is generated each year.
- 1,000 gallons of new fixer must be purchased each year at $27.00/4 gal.
- 1,000 gallons of new developer must be purchased each year at $35.00/4 gal.
- Cost of traditional X-ray film and paper used to print CR images is equivalent.
- Labor/hours to operate traditional X-ray and digital X-ray is equivalent (i.e., same amount of time to take the same number of X-rays).

i. Implementation Costs. Implementation costs would be obtained from the initial purchase of the Digital Radiography System. It is assumed labor to install the system, and initial training of technicians to operate the new system, are included in the purchase price.

> *Digital Radiography System*: For this example, a Canon Digital Radiography Upright System CXDI-11, which includes generator, monitor, software, floor/railing tubestand = $345,000
> *Optional Laser Printer*: $45,000

Total Implementation Costs: $345,000 + $45,000 = $390,000

ii. Recurring Costs. Recurring costs would be incurred from the operation of the digital radiography equipment. It is assumed that the operational costs of the traditional X-ray system would be comparable to the digital X-ray system, resulting in no net recurring costs.

iii. Recurring Cost Savings. Recurring cost savings would be realized from no longer having to purchase developer and fixer, and from no longer having to pay to dispose of the spent fixer as an HW.

> *Avoided Purchase of Fixer*: 1,000 gal/yr x $27.00/4 gal = $6,750/yr
> *Avoided Purchase of Developer*: 1,000 gal/yr x $35.00/4 gal = $8,750/yr
> *Avoided Disposal Costs of Spent Fixer*: 7,506 lb/yr x $1.25/lb = $9,383/yr

Total Recurring Cost Savings: $6,750/yr + $8,750/yr + $9,383/yr = $24,883/yr

iv. Payback Period. The payback period for this initiative is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

$$\frac{\$390{,}000}{(\$24{,}883/\text{yr} - \$0/\text{yr})} = 15.7\ \text{yr}$$

Results will vary for each MTF. It is important to use information pertaining to the MTF's unique situation (e.g., actual use of current X-ray imaging system or actual cost of digital system to meet their needs) when evaluating the useful potential of this initiative. Implementing this initiative would result in additional ancillary savings not contained in the calculation above. These savings would include reduction in water usage (the digital system does not require rinse water for the X-ray developing process), no need to purchase and maintain spill kits for chemicals that are no longer needed, no labor or waste disposal from cleaning up spills of said photochemicals, and a reduction in time and labor required to train personnel to handle and mange the HW generated by the X-ray developing process, as there is no more HW generated.

2.2.1.1.3 Potential P2 Initiative - Digital Mammography

Currently, the United States Food and Drug Administration (FDA) has approved three pieces of equipment for digital mammography: the General Electric Medical Systems (GEMS) Seneographe® 2000D Full Field Digital Mammography (FFDM) System, the Fischer Imaging Corporation SenoScan® FFDM System, and the Hologic, Incorporated LORAD Selenia™ FFDM System. The FDA has also developed the following requirements for mammography facilities to meet in order to be FDA certified for digital mammography.

FDA certified digital mammography facilities must:

- Receive specific written approval from FDA before the unit can be used to examine patients;
- Perform all quality control tests in the timeframes required by the manufacturer;
- Undergo a yearly inspection by trained Federal or State personnel;
- Be surveyed yearly by a medical physicist; and
- Meet quality standards for personnel, equipment, record keeping, and reporting.

Bottom line cost is approximately $500,000 initial start up, which includes the X-ray device, acquisition console, ($325,000 for instrument and console), film handling device (laser printer) ($80,000), and review work station (for radiologist) ($100,000). Equipment comes with a 1-year warranty and a service contract (beginning year 2), which is about $50,000/yr.

Equipment operation training for the technologist and radiologist is provided as part of the purchase cost, as there is a learning curve for the radiologist to learn how to read the digital images. In the near future, FDA will require that the equipment must be placed in a location accredited by the American College of Radiology (ACR). However, since the technology is new, the ACR is currently developing the criteria for accreditation. In the interim, the FDA is directly certifying the equipment facilities. Also, this equipment could also be placed at a remote location (telemedicine) and the image transmitted to a radiologist for review. Economy of scale could be achieved at larger facilities with the need to purchase only one or two film handling devices and review workstations that could be networked.

The footprint and utility needs (220v/30amp) of the equipment are no different than current equipment on the market. The life cycle is not yet known, however, a conservative estimate would be of 7 years with a 3.5-year technology upgrade.

The systems are approved for both hard copy (printed) and soft copy (monitor) readings. The limiting factor for some of the systems may be the size of the receptor that holds the breast during imaging; 25-40% of the population requires a large receptor (24 x 30 cm) where a small receptor usually measures 18 x 24 cm. For example, the GE system is most suited for patients requiring small receptors.

® Seneographe is a registered trademark of General Electric (GE) Company, Fairfield, Connecticut.
® SenoScan is a registered trademark of Fischer Imaging Corporation, Denver, Colorado.
™ Selenia is a trademark name of Hologic, Incorporated, Bedford, Massachusetts

2.2.1.2 Waste Generated – Used X-Ray Film

Another waste stream is scrap X-ray film. X-ray film contains silver and this silver can be recovered instead of simply discarding unneeded films. The scrap film can be sent through the local DRMO, which should be able to recycle the silver as part of its precious metals recovery program. While this initiative does not reduce the number of scrap X-ray films produced, it does provide a way for the MTF to recycle potential HW with no additional costs incurred by the MTF.

2.2.2 Laboratory Chemicals

2.2.2.1 Potential P2 Initiative – Distillation of Laboratory Chemicals

a. Discussion. Because of their role in tissue processing, formalin, ethyl alcohol, and xylene are among the most common chemicals used in MTF laboratories. Formalin, an aqueous solution of approximately 37% formaldehyde (and some buffer salts), is typically diluted to 10% and used as a fixative to preserve tissue samples until they can be prepared for viewing. Once the tissue has been removed from the fixative, the formalin is typically disposed of via the sanitary sewer.

To prepare tissue samples for viewing, the tissue must be sliced, placed onto slides, and stained. However, before a tissue sample can be sliced, the water within its cells must first be replaced by paraffin, which gives the tissue a rigid structure and prevents the cells from becoming distorted by the cutting blade. This replacement process involves submerging the tissue in a series of graded ethanol solutions, then xylene, then paraffin. Once cut, the tissues slices (containing paraffin) must then be taken through the graded series in reverse to restore the water in the cells, allowing them to be stained. Then, the stained samples are taken back through the series one last time to replace the water with paraffin for long-term preservation. Once a predetermined number of samples have been processed, the used ethanol and xylene, having become contaminated, must then be disposed of as an HW under RCRA.

As an alternative to disposing of these used chemicals, distillation provides a mechanism to reclaim and reuse them. Distillation separates a liquid from its contaminants by heating the liquid until it vaporizes. The vapors are then collected and condensed while the contaminants are left behind in the boiling chamber as still bottoms. Distillation can be used to recover formalin, ethanol, and xylene. However, the process for recovering formalin differs from that used to recover ethanol and xylene. This difference results from the chemical nature of each of these waste streams.

Formalin is typically contaminated only with tissue particles. As a result, the distillation process only has to separate the formalin from particulate contamination. This can be accomplished with a process known as simple distillation. Simple distillation is used to separate volatile components from nonvolatile ones. Therefore, the water and formaldehyde in the formalin mixture will be vaporized, condensed, and collected while the nonvolatile tissue cells or particles will comprise the still bottoms. The distilled formalin will have the same, or very nearly the same, concentrations of formaldehyde and water as did the original formalin. One drawback, however, is that any buffer salts in the formalin will remain behind as still bottoms. Therefore, before reuse, it is necessary to replenish these salts. Premeasured salt kits are available from various formalin distillation unit manufacturers, and can be added to replenish each batch of formalin after it has been processed. Test kits are also available to help assure that the formalin has been restored to specifications.

The recovery of used ethanol and xylene is more complicated because they are contaminated not only with particulate but also with other volatile substances. If the laboratory segregates its used ethanol and its used xylene, the ethanol will probably be contaminated with tissue cells as well as volatile substances such as water, formalin, and tissue stains. The used xylene could be contaminated with tissue cells, paraffin, and ethanol. If a laboratory does not practice waste segregation, its waste will contain any or all of the above.

Separating a mixture of multiple volatile compounds into its various constituents (or fractions) requires a process known as fractional distillation. Fractional distillation relies on each volatile constituent having different vaporization and condensation temperatures than the other constituents in the mixture.

b. Technical Evaluation. Distillation equipment is available in many different sizes. For smaller batches there are units with 5- or 10-gallon process tanks, for medium operations there are units with 15- or 25-gallon process tanks, and for large operations there are units with 55-gallon process tanks.

Some of the smaller units can be placed on bench tops or can be mounted on portable carts, while the larger units are fixed, floor-type units.

Some units require water hookup for cooling the unit, while others do not require water and use air instead so that no water or drain is required.

The length of time to recycle a batch of solvent depends on the type of material being recycled, the volume being recycled, and the type of recycling system used. Typically, for a unit with a 5-gallon process tank it takes approximately 4 hours to recycle xylene, 6 hours to recycle alcohol, and 10 hours to recycle formalin.

Power requirements vary by make and model, but the small and medium units usually require 110/120v, 50/60 Hz, 7-15 amps. The larger units usually require 220-240 volts, 50/60 Hz, 3-8 amps.

c. Environmental Evaluation. For waste ethanol (contaminated with water and tissue stains), fractional distillation can recover up to 90% of the ethanol (with 10% left behind in the still bottoms). The distilled ethanol will be up to 95% pure (with water as the remaining 5%). For waste xylene (contaminated with ethanol and water), fractional distillation can recover up to 95%

of the xylene (with 5% left behind in the still bottoms). The distilled xylene can be up to 100% pure. For laboratories with combined waste streams (used ethanol and xylene mixed), most fractional distillation units would only be effective in recovering the xylene portion of the waste stream. As a result, it is recommended that histology laboratories maintain proper waste segregation.

Table 1 provides a summary of the above information. Note that as an alternative to onsite distillation, contractors may also be available to collect laboratory wastes, distill them offsite, and return the recycled product.

Table 1. Distillation Unit Summary.

Substance	Distillation Type	Percent Recovered	Percent Pure
Formalin	Simple	90	100*
Ethanol	Fractional	90	95
Xylene	Fractional	95	100

* After replenishing with buffer salts.

d. Economic Evaluation. For this example, the following assumptions are made:

- Distillation units are approximately 90% efficient, so distillation will reduce the required purchase and disposal volumes and costs by 90%. The only waste stream associated with distillation will be still bottoms.
- All spent formalin is disposed of down the sanitary sewer at no cost.
- All spent ethanol is disposed of as HW at a cost of $0.70/lb.
- All spent xylene is disposed of as HW at a cost of $0.70/lb.
- 80 gal/yr of spent formalin is generated.
- 120 gal/yr of spent ethanol is generated.
- 80 gal/yr of spent xylene is generated.
- 80 gal/yr of new formalin is purchased at a cost of $20/gal.
- 120 gal/yr of new ethanol is purchased at a cost of $14/gal.
- 80 gal/yr of new xylene is purchased at a cost of $10/gal.
- Electricity costs $0.065/kW hr

i. Implementation Costs. Implementation costs would come from the initial purchase of the formalin distillation unit and the xylene/ethanol distillation unit. It is assumed that labor to install the system and initial training of technicians to operate the new system are included in the purchase price.

Formalin Distillation Unit: For this example, a B/R Instrument Corp. model 2100, 10 gal capacity = $16,275
Xylene/Alcohol Distillation Unit: For this example, a B/R Instrument Corp. model 9700, 4.5 gal capacity = $10,835

ii. Recurring Costs. Recurring costs would be from disposal of still bottoms from the distillation units (assumed to be equal to 10% of current waste); purchase of new formalin, xylene, and ethanol that is lost during the distillation process (assumed to be equal to 10% disposed of above); purchase of buffer salts required to be added after formalin is distilled; and the electrical cost to operate the distillation units.

Disposal of Formalin: (80 gal/yr x 0.10) x $0/gal (sanitary sewer, no cost) = $0/yr
Disposal of Ethanol: (120 gal/yr x 0.10) x $0.70/lb x 6.6 lb/gal = $55/yr
Disposal of Xylene: (80 gal/yr x 0.10) x $0.70/lb x 7.2 lb/gal = $40/yr

Purchase of Formalin: (80 gal/yr x 0.10) x $20/gal = $160/yr
Purchase of Ethanol: (120 gal/yr x 0.10) x $14/gal = $168/yr
Purchase of Xylene: (80 gal/yr x 0.10) x $10/gal = $80/yr

Purchase of Formalin Buffer Salts: 80 gal/yr x $8/5 gal = $128/yr

Power Costs = Power requirements x Operating Hours x Electricity Costs

Power Cost, Formalin Distillation:
Power Requirements = 15 amps x 115 volts = 1.8 kW
Operating Hours = 80 gal/yr x 12 hr/5 gal batch = 192 hr/yr
Electricity Costs = $0.065/kW hr
Formalin Power Costs = 1.8 kW x 192 hr/yr x $0.065/kW hr = $22/yr

Power Cost, Ethanol Distillation:
Power Requirements = 20 amps x 120 volts = 2.4 kW
Operating Hours = 120 gal/yr x 7 hr/5 gal batch = 168 hr/yr
Electricity Costs = $0.065/kW hr
Ethanol Power Costs = 2.4 kW x 168 hr/yr x $0.065/kW hr = $26/yr

Power Cost, Xylene Distillation:
Power Requirements = 20 amps x 120 volts = 2.4 kW
Operating Hours = 80 gal/yr x 5 hr/5 gal batch = 80 hr/yr
Electricity Costs = $0.065/kW hr
Xylene Power Costs = 2.4 kW x 80 hr/yr x $0.065/kW hr = $12/yr

Total Recurring Costs, Formalin: \$0/*yr* + \$160/yr + \$128/yr + \$22/yr = \$310/yr
Total Recurring Costs, Ethanol: \$55/yr + \$168/yr + \$26/yr = \$249/yr
Total Recurring Costs, Xylene: \$40/yr + \$80/*yr* + \$12/yr = \$132/yr

iii. Recurring Cost Savings. Recurring costs savings would come from no longer having to dispose of 90% of the current waste formalin, ethanol, and xylene; and from no longer having to purchase new formalin, xylene, and ethanol to replace the 90% that is distilled.

Avoided Disposal Costs, Formalin: (80 gal/yr x 0.90) x \$0/yr (sanitary sewer) = \$0/yr
Avoided Disposal Costs, Ethanol: (120 gal/yr x 0.90) x \$0.70/lb x 6.6 lb/gal = \$499/yr
Avoided Disposal Costs, Xylene: (80 gal/yr x 0.90) x \$0.70/lb x 7.2 lb/gal = \$363/yr

Avoided Purchase, Formalin: (80 gal/yr x 0.90) x \$20/gal = \$1,440/yr
Avoided Purchase, Ethanol: (120 gal/yr x 0.90) x \$14/gal = \$1,512/yr
Avoided Purchase, Xylene: (80 gal/yr x 0.90) x \$10/gal = \$720/yr

Total Recurring Cost Savings, Formalin: \$0/yr + \$1,440/yr = \$1,440/yr
Total Recurring Cost Savings, Ethanol: \$499/yr + \$1,512/yr = \$2,011/yr
Total Recurring Cost Savings, Xylene: \$363/yr + \$720/yr = \$1,083/yr

iv. Payback Period. The payback period for this initiative is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

Formalin:

$$\frac{\$16{,}275}{(\$1{,}440/\text{yr} - \$310/\text{yr})} = 14.4\ \text{yr}$$

Xylene/Ethanol:

$$\frac{\$10{,}835}{(\$2{,}011/\text{yr} + \$1{,}083/\text{yr}) - (\$249/\text{yr} + \$132/\text{yr})} = 4\ \text{yr}$$

Due to the low volume of formalin generated and the relatively high implementation cost, the distillation of formalin is not economically feasible because the payback period may be longer than the actual useful lifetime of the distillation unit. A decrease in the implementation costs, and/or an increase in the volume of formalin used would contribute to a more favorable payback period.

One distillation unit can be used for recycling both xylene and ethanol. The payback period calculation here combines the data for both in order to increase the possibility of a favorable payback period.

2.2.2.2 Potential P2 Initiative – Xylene Substitutes

Xylene substitutes are another P2 initiative available to reduce or eliminate the xylene used in the tissue preparation process (and subsequently disposed of as an HW). There are currently several commonly used substitutes that have been proven to work as effectively as xylene in most histology applications (e.g., Slidebrite, Histoclear, or Americlear). One drawback to these substitutes, however, is that they may have a much lower flash point than xylene and are classified as a RCRA HW under the ignitability characteristic once they become spent. As a result, xylene substitutes do not actually reduce the amount of HW generated by a histology laboratory; they merely provide a less hazardous option.

Like xylene, some xylene substitutes may be able to be recovered in a distillation unit. This will depend on whether or not the substitute contains any nonvolatile additives that would be lost in the distillation process. Before changing to a xylene substitute, laboratories that are already distilling xylene should contact their still's manufacturer to determine if it can economically recover the substitute.

2.2.2.3 Potential P2 Initiative – Formalin Substitutes

One of the most successful ways to prevent pollution is by substituting a hazardous chemical with a less hazardous chemical. For many laboratory methods, an environmentally sound alternative exists. Some alternatives to using formalin (formaldehyde) as a tissue preservative and fixative in the laboratory setting include the alcohol fixatives NoToxhisto®, Prefer, or Omnifix. As with the xylene substitutes listed above, the formalin substitutes should be evaluated to determine if they perform to the laboratory's expectations, and if they have any hazardous components or characteristics that would also make them a RCRA HW when disposed. These substitutes may not reduce the HW generated, but provide a less hazardous option.

2.2.2.4 Potential P2 Initiative – Picric Acid Management/Substitutes

a. Description. Picric acid (2,4,6-trinitrophenol) is a toxic yellow crystalline solid that melts at 122^{o}C and is soluble in most organic solvents. Picric acid may be found at MTFs as a component of Bouin's fixative solution, which is used in the histology lab for fixing tissue samples and staining them. Bouin's solution may either be purchased pre-made, or be produced and used in the lab by combing picric acid, formalin (formaldehyde), and glacial acetic acid. In cases where the Bouin's solution is made at the MTF, picric acid is normally purchased as a flammable solid, wetted with at least 30% water. If stored for an extended period of time, picric acid can dehydrate. When less than 10% water is present, the dry picric acid crystals may be shock, heat and friction sensitive. It also reacts with metals to form metal picrates, which like picric acid itself are highly sensitive explosives that can be detonated by heat, flame, shock, or friction. There have been instances where the discovery of old bottles of picric acid has required removal by local bomb squads. Because of the safety concerns with handling and storing picric acid, the purchase and use of pre-made Bouin's solution is recommended, as is the use of alternative fixing agents that do not contain picric acid.

b. Technical Evaluation. Pre-made Bouin's solution is commercially available, such that the laboratory will not need to purchase picric acid in order to make its own solution. This

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eliminates most of the handling and storing precautions that must be taken when using picric acid. The picric acid in the Bouin's solution is considered saturated and is unlikely to form crystals under normal conditions of use and storage. Care should be taken to ensure that crystals are not allowed to form during use of the solution by wiping the threads of the container and cap after pouring. It is also recommended that any solution containing picric acid be disposed of within 2 years of initial receipt.

Alternative fixatives are also commercially available, or may be made in the lab, which do not contain picric acid. These include Zenker's, Helly's, and a modified Davidson's fixative. As with all product substitutions, the MTF should physically verify that the alternative chemical(s) will perform as expected without jeopardizing the MTF's mission.

c. Environmental Evaluation. Use of the pre-made Bouin's solution does not eliminate or reduce the amount of Bouin's solution used in the lab, but does eliminate picric acid stored in the lab that may degrade during storage and eventually require disposal as a hazardous waste.

While neither the Zenker's and Helly's fixatives have explosive hazards, they may be less preferable alternatives because they both contain potassium dichromate and mercuric chloride (mercury containing compounds in particular are something that the medical community is trying to reduce the use of and subsequent release to the environment). A third possible alternative is a modified Davidson's fixative, which has been validated as a safer and more environmentally acceptable replacement. Its primary ingredients are ethanol, acetic acid and formalin (formaldehyde). Table 2 compares the hazards and compositions of the above referenced fixatives. Additional mercury-free alternatives may be available, see Section 2.2.4 below.

Because of their composition, these substitutes may not reduce the HW generated, but provide a less hazardous option.

Table 2: Comparison of Laboratory Fixatives

Fixative	**Hazards**	**Ingredients (approximate % by volume)**
Bouin's Solution	Explosive, Corrosive, Carcinogen, Irritant, Toxic	71% Picric acid (saturated aqueous solution) 24% Formaldehyde solution (37-40% concentrated) 5% Glacial acetic acid
Davidson's Fixative (modified)	Flammable, Irritant, Toxic	30% Formaldehyde (37-40%) 15% Ethanol 5% Glacial Acetic Acid 50% Distilled Water
Helly's Fixative	Toxic	68% Mercuric chloride (saturated aqueous solution) 26% Potassium dichromate (sat. aqueous solution) 4% Sodium sulfate (25% aqueous solution) 2% Formalin
Zenker's Fixative	Carcinogen, Irritant, Toxic	68% Mercuric chloride (saturated aqueous solution) 26% Potassium dichromate (sat. aqueous solution) 4% Sodium sulfate (25% aqueous solution) 2% Glacial acetic acid

d. Economic Evaluation. Because this is a relatively straightforward product substitution, no economic evaluation has been performed. The replacement solutions are generally comparable in cost to the Bouin's solution, but disposal costs may vary depending on the chemicals that make up the alternative solutions.

2.2.2.5 Potential P2 Initiative – Neutralize Formalin

Ten percent formalin acts as a tissue preservative and replaces the more toxic pure formaldehyde. Used formalin may typically be disposed of via the sanitary sewer (unless there are local wastewater regulations prohibiting such a practice). In areas where the used formalin cannot be disposed via the sanitary sewer, it can be treated prior to disposal. Treatment of the formalin with a chemical product such as Neutralex®, VYTAC™ 10F, Form-X™ Formalin Neutralizer, Formalex®, or D-Formalizer® neutralizes the used formalin and renders the waste nonhazardous; other products may be on the market. According to available data, all of these products will reduce the concentration of a treated sample of formalin to under 0.1 percent formaldehyde. According to product literature, both "Neutralex" and "D-Formalizer" will reduce the concentration to less than 25 ppm in 15 minutes. Please note that some of these neutralizers may result in a precipitate requiring filtering. Adjustment of the pH and filtering of solid residues may be required following treatment.

2.2.3 Expired Pharmaceuticals

Another significant waste stream can be expired pharmaceuticals generated at the MTF pharmacy. This waste source can be reduced through source reduction and improved management operations.

2.2.3.1 Prime Vendor Management

One way to accomplish source reduction is to have the pharmacy participate in the Prime Vendor Program. This program orders medications and pharmaceuticals on an as-needed basis from an established group of pharmaceuticals vendors. In the past, large volumes of medications and medical supplies were ordered and stockpiled based on anticipated patient load, but many of these medications were time sensitive and expired before they were used. Expired items were destroyed causing a financial loss. The Prime Vendor system reduces stockpiling and has cut costs through the reduction of expired medical supply disposal.

2.2.3.2 Return to Vendor for Credit

Another initiative to reduce pharmacy waste is the return of expired items to the vendor for credit, usually through the use of a third party vendor returns company. Through this system, expired pharmaceuticals are collected from an MTF and any outlying clinics on an installation

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® Formalex is a registered trademark of S&S Company of Georgia, Inc., Albany, Georgia.
® D-Formalizer is a registered trademark of Surgipath Medical Industries Inc., Richmond, Illinois.

and are consolidated. The returns company picks up the items from the MTF on a regular basis. The vendor accepts the expired pharmaceuticals and then credits the MTF through the Prime Vendor system. Items not taken by the returns company are disposed of in accordance with the Military Items Disposal Instructions System. Documentation should be maintained of the waste volume and return value credited to the MTF so that a quantitative assessment of the program's cost effectiveness can be verified.

Certain items, such as epinephrine, are hazardous drugs as defined by RCRA. Expired medications with epinephrine as the sole active ingredient are acutely HW as defined in Section 261.33(e) of Title 40, Code of Federal Regulations (CFR). Once RCRA-hazardous items expire, they become HW and must meet appropriate handling, manifesting, and shipping requirements. Care should be taken to document expiration dates and to ensure that RCRA-hazardous items are handled as HW when they expire. The capability to return expired RCRA-hazardous items to a third party service company varies by state. In cases where it is not allowed, policies should be in place to return the soon-to-expire items to the returns vendor before the expiration date is reached. Verify which policy should be followed at the MTF by contacting the appropriate State office, or contacting the USACHPPM Hazardous and Medical Waste Program, which has a Fact Sheet entitled "Classification of Waste Pharmaceuticals" explaining this matter in greater detail.

2.2.4 Mercury Containing Products Found in Laboratories

Tables 3 through 10 describe common items found in Army MTFs. The items shown in the first three tables (Tables 3, 4, and 5) describe reagents and common processes, chemicals and chemical containing kits, and pharmaceuticals, respectively, that contain small amounts of mercury. These items should be identified and efforts should be taken to minimize or eliminate their use when possible. When this is not deemed feasible, great care should be used to ensure they are not disposed of in a manner that could pollute the environment with mercury (i.e., disposal in wastewater, landfills, or through incineration).

The information in Table 3 was originally published by Robert K. Gingras, P.E., DEE, Earth Tech, Inc., Concord Massachusetts, and presented at the Pollution Prevention Strategies for Health Care Industry meeting in 1998, sponsored by the Boston University Corporate Education Center. This list should not be assumed to be complete. It must also be pointed out that the regulatory limit for mercury is 200 parts per billion (ppb) or 0.20 mg/L.

Table 4 lists the wide variety of laboratory chemicals that may contain mercury. The mercury may have either been added purposely as part of the manufacturing process, or the product may contain mercury as a contaminant in a feedstock. If mercury is a contaminant, its presence or absence may vary from lot to lot. In the case of kits, it is necessary to consider separately each of the reagents that may make up the kit. This list should not be assumed to be complete.

Potential P2 Initiative – Product Substitution

a. Description. Mercury spills are the most common chemical spill. Thermometers, manometers, blood pressure cuffs, and many other instruments used in an MTF contain elemental mercury and are easily broken. If a broken mercury thermometer isn't cleaned up properly, the mercury can get into the air and pose a health risk. Substituting solid-state electronic sensing devices for mercury-containing devices used to monitor temperatures and blood pressure is the primary minimization alternative for mercury wastes in MTFs.

b. Technical Evaluation. Implementation of this initiative is relatively easy, with selecting an appropriate replacement and disposing of the mercury-containing device in an environmentally sound manner. Digital thermometers, electronic sensors, alcohol/organic liquid filled thermometers, and temperature strips are readily available alternatives to mercury thermometers. Blood pressure cuffs with electronic sensors are available. Esophageal dilators, Cantor tubes, and Miller Abbot tubes can be found with tungsten weighting instead of mercury. The accuracy of these replacement devices is generally acceptable when maintained and serviced (calibrated) according to manufacturer's specifications.

c. Environmental Evaluation. Replacing these mercury-containing devices with non-mercury containing ones is the most direct way to remove the potential hazards a mercury spill can create from the MTF, reducing potential personnel and patient exposure and HW disposal of spill residue. Tables 6 through 10 present lists of chemicals and mercury containing equipment (sphygmomanometers, manometers, thermometers, and gastrointestinal tubes), along with suggested nonmercury alternatives.

d. Economic Evaluation. Because this is a relatively straightforward product substitution, no economic evaluation has been performed. While the replacement devices generally cost more than their mercury-containing counterparts, the cost can be considered as being comparable when the associated high disposal cost of the mercury-containing devices are included.

Table 3: Processes and Reagents Found to Contain Mercury

AUTOANALYZERS	*CONCENTRATION, ppb*	*REAGENTS*	*CONCENTRATION, ppb*
Autodelfia	3.1	Trichrome Blue Stain	7.1
Iris	0.3	TB Decolorizer	65.6
Cotter	0.3	Formalin	25.8
Technicon H2	0.4	Bouins	46.6
Hitachi	0.3	B-5 Fixative	148.4
Chem-Array	0.4	Effect II	23.3
Chem-IMX-1	0.4	Aldex	99.9
Chem-IMX-2	0.4	RDO	24.6
Chem-654	0.4	Sponge Exudate	124.6
Chem-Autodelfia	0.8		
Chem-SEC	0.9		
HEME MDA	2.1		

Table 4: Additional Chemicals/Kits that May Contain Mercury

Acetic Acid	Immu-sal
Ammonium reagent/Stone analysis kit	Liquid substrate concentrates and diluents
Antibody test kits	Negative control kits
Antigens	Phenobarbital reagent
Antiserums	Phenytoin reagent
Buffers	Positive control kits
Calibration kits	Potassium hydroxide
Calibrators	Pregnancy kits
Chloride	Rabbit serum
Conjugate kits	Shigella bacteria
Diluents	Sodium hypochloride
Enzyme immunoassay test kits	Stains
Enzyme tracers	Standards
Ethanol	Substance abuse test kits
Extraction enzymes	Sulfuric acid
Fixatives	Thimerosal
Hematology reagents	Tracer kits
Hormones	Urine analysis reagents
Immunoelectrophoresis reagents	Wash solutions
Immunofixationphoresis reagents	

Table 5: Pharmaceuticals Containing Mercury

PRODUCT	*NOTES*
Merbromin/water solution	Used in plastic/reconstructive surgery as a disinfectant and marker.
Ophthalmic and contact lens products	May contain mercury preservatives: Thimerosal, phenylmercuric acetate, phenylmercuric nitrate.
Nasal sprays	May contain mercury preservatives: Thimerosal, phenylmercuric acetate, phenylmercuric nitrate.
Vaccines	May contain Thimerosal (primarily in hemophilus, hepatitis, rabies, tetanus, influenza, diphtheria and pertussis vaccines).
Homeopathic medications	At least 17 compounds used, many as applications.
Hemorrhoid ointments and creams	Used as preservative, discontinued in early 1995.

Table 6: Alternatives for Mercury-Containing Laboratory Chemicals

COMPOUND	*POSSIBLE ALTERNATIVES*
Histological fixatives (such as B5 and Zenker's Solution) with mercury (II) chloride as a tissue preservative	Freeze-drying, zinc formalin; other products are available that are both mercury-free and formaldehyde-free.
Mercury (II) chloride as an oxidizer in hematoxylin	Sodium iodate as oxidizer.
Chemical used for acidic drug analysis of barbiturates and benzodiazepines by thin layer chromatography (such as Toxi-Dip B3)	Gas chromatography/mass spectrometry method. A medical treatment facility may need to send samples to a lab that has the equipment and specially trained staff required.
Thimerosal (Trademark Merthiolate) as a preservative in stains and other products in the pH neutral range	Methyl paraben, propyl paraben.
Mercury (II) oxide, mercury (II) sulfate, mercury iodide, mercury nitrate	Appropriate alternatives for these compounds should be based on your procedure. Possible alternatives include silver nitrate/potassium/chromium- (III) sulfate instead of mercury (II) sulfate.
Staining solutions and preservatives such as Immu-sal, Carbol-fuchin stain, Gram iodine stain, phenolic mercuric acetate, alum, Hematoxylin "Solution A"	Replace with a variety of chemical compounds. Some substitutes such as copper, tin, and chromium compounds also have a risk, but less than the risk associated with mercury.

Table 7: Alternatives for Mercury-Containing Sphygmomanometers

TYPE OF SPHYGMOMANOMETER	*COST*	*COMMENTS*
Aneroid	Wall model, adult: $50–$80; Portable model, adult: $30–$35	Needs calibration annually. Accuracy comparable to mercury.
Electronic	Approximately $2,000	Common where long-term continuous monitoring is needed, such as intensive care.
Mercury	Wall model, adult: $60–$70	Requires annual refilling and calibration. Expensive disposal.

Table 8: Alternatives for Mercury-Containing Laboratory Manometers

TYPE OF MANOMETER	*COST*	*COMMENTS*
Electronic (digital)	Several hundred dollars	An order of magnitude more accurate than sphygmomanometers. Used in biomedical laboratory to calibrate other devices. A traceable calibration must be performed with a mercury manometer, onsite or offsite, on a regular schedule.
Aneroid (Bourdon, diaphragm, piston or capsule types)	Price varies depending on accuracy	Manufactures recommend calibration at least annually.
Liquid filled	Price varies depending on accuracy	Inadvisable to move them from place to place. Manufacturers recommend calibration at least annually.
Mercury	$100-$150 range	One meter tall. An order of magnitude more accurate than sphygmomanometers. Used in biomedical laboratory to calibrate devices. Annual calibration recommended.

Table 9: Alternatives for Mercury-Containing Thermometers

TYPE OF THERMOMETER	*COST*	*ACCURACY*	*TIME FOR READING*	*CALIBRATION FREQUENCY*	*COMMENTS*
Electronic (digital): oral/rectal	Thermometer approx. $300. Disposable covers: pennies a piece	Comparable to mercury	Oral: seconds Rectal: seconds	Every 6 mo. - 1 year. Some need initial testing only	Requires batteries
Electronic (digital): tympanic (also called infrared thermometer)	Thermometer approx. $300. Covers: pennies a piece	Comparable to mercury	Seconds	Every 6 mo. - 1 year. Some need initial testing only.	Requires batteries. Must use "pull and tug" method to get correct placement.
Glass filled with alloy of gallium, indium, and tin (liquid at room temperature).	Approximately $3	Comparable to mercury	3 minutes	None required	Breakable
Mercury	Approximately $0.40	Considered being the "standard"	Oral: 5 min Rectal: 7 min	None required	Breakable. Expensive disposal.

Table 10: Alternatives for Mercury-Containing Gastrointestinal Tubes

TYPE OF GASTROINTESTINAL (GI) TUBE	*MERCURY-FREE ALTERNATIVE AND EFFECTIVENESS*
Bougie Tubes (esophageal dilators)	Tungsten. Considered to be as effective as mercury.
Cantor tubes (used to trace the GI tract)	Tungsten. Can be purchased empty of weighting and medical treatment facility adds the tungsten.
Miller Abbott tubes (used to clear intestinal obstruction)	Tungsten. Can be purchased empty of weighting and medical treatment facility adds the weighting material. Tungsten is considered to be as effective as mercury.
Feeding tubes	Tungsten. Considered being as effective as mercury.

CHAPTER 3 - REGULATED MEDICAL WASTE

3.1 DESCRIPTION

Inherent to the treatment of patients, medical facilities generate potentially infectious waste or regulated medical waste (RMW). The definition of RMW varies among State and local regulatory bodies, but generally involves items containing blood and blood products, sharps such as syringes, laboratory cultures, animal research wastes, and isolation wastes. This chapter describes two main P2 opportunities for RMW: proper management and treatment.

3.2 MANAGEMENT

The management of RMW is dependent on the input into the waste stream made by the various clinics and wards throughout an MTF. Thus, two effective management tools for RMW P2 are segregation and durable medical item procurement.

3.2.1 Segregation

a. Description. Segregation involves separating the RMW at the source of generation by distinguishing between which items belong in general solid waste trash receptacles and which items must go in appropriate RMW containers for disposal. Increased segregation reduces disposal, labor, and maintenance costs by removing non-RMW from the RMW stream. This P2 initiative is easily implemented through management controls.

b. Technical Evaluation. Simple management tools can be applied to alleviate most segregation problems: training in RMW, posting signage, and limiting access to RMW bags.

Site-specific RMW training should be provided to all employees within an MTF. This training should include the local definition of RMW, proper waste segregation, and the standard operating procedure for its handling. Besides volume reduction, training eliminates confusion and frustration among the generators and handlers of RMW over which wastes belong in the RMW bags.

Posting signs near RMW bags throughout the facility stating the items that are defined as RMW serves as a simple reminder that general trash is not an RMW. Periodic spot checks for proper segregation can be used to evaluate the effectiveness of the training and posted signs.

A third management tool for effective segregation is limiting access to RMW bags. Limiting access involves removing RMW bags from diagnostic treatment room receptacles and storing them in a nearby cabinet or drawer. This reduces the convenience of placing the general trash in the nearest container instead of the appropriate one while providing for instances when an RMW bag is warranted.

c. Environmental Evaluation. The most common P2 initiative for RMW is waste segregation. Typically, significant amounts of plastic wrapping, rubber gloves, paper, and glassware with an occasional candy wrapper are found in the RMW stream. Not only does poor segregation generate larger RMW volumes and higher disposal costs (for items that could otherwise be disposed of as municipal solid waste (MSW) or possibly be recycled), but depending on the treatment method, these non-RMW items may adversely affect the functional life of the RMW treatment equipment. For example, RMW with high plastic content creates more hydrochloric acid during incineration, resulting in increased incinerator maintenance and shorter incinerator operating life.

d. Economic Evaluation. For this example, the following assumptions are made:

- MTF generates approximately 3,000 lb RMW/yr
- Cost to dispose of RMW is $0.29/lb
- Cost to dispose of MSW is $0.025/lb
- Assume 20% of the RMW now being disposed of is normal MSW. Then the total MSW being improperly disposed of is 600 lb/yr (3,000 lb/yr x 0.20)

i. Implementation Costs. The only economic considerations associated with implementing this initiative would be the initial training of the employees at the MTF, which can be incorporated with other training they currently receive at no significant cost, and the production of the signs to be posted, which can be done in-house at no significant cost.

ii. Recurring Costs. Again, refresher training for the employees can be incorporated with other annual training they receive at no significant cost to the MTF. The only other recurring cost would be the disposal cost of the MSW that has been diverted from the RMW stream. For this example, it is assumed that 10% of this MSW is diverted from the RMW bags and containers.

Recurring Costs = 600 lb/yr x 0.10 x $0.025/lb = $1.50/yr

iii. Recurring Cost Savings. The recurring cost savings would be realized from no longer disposing of diverted 10% MSW as the more expensive RMW.

Recurring Cost Savings = 600 lb/yr x 0.10 x $0.29/lb = $17.40/yr

iv. Payback Period. The payback period for this initiative is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

$$\frac{\$0}{(\$17.40/\text{yr} - \$1.50/\text{yr})} = \text{Immediate}$$

Because there are no significant implementation costs, and the recurring cost savings are larger than the recurring costs, the payback period is immediate for this initiative, albeit small. Because this calculation is based on an estimated percentage of waste that is being improperly disposed, the larger the amount of waste generated by the facility, the larger the amount of money that will be saved.

3.2.2 Durable Medical Item Procurement

a. Description. In recent years, MTFs have moved away from durable and reusable medical products to using disposable products. Depending on the type of item and how it is disposed of, this practice has increased the volume of solid waste and RMW generated by MTFs. Effective procurement is a valuable P2 tool for reducing the amount of RMW generated and the costs associated with RMW management and disposal.

b. Technical Evaluation. Purchasing durable medical items like linens and metal instruments that can be washed, sterilized if needed, and reused, reduces RMW and MSW generation. Often, paper treatment table covers and disposable instruments, like scissors and clamps, are purchased for the user's handling convenience. The item is used once and then deposited in a sharps container or RMW bag. Not only does this increase RMW generation, it increases disposal cost. Many durable medical products have been developed that are labeled by the manufacturers as "single use" devices (SUDs), even though they are reusable with proper reprocessing and sterilization techniques. A list of SUDs known to be reprocessed is available at the FDA website: http://www.fda.gov/cdrh/reuse/1168a.pdf. Note, however, that reprocessing SUDs may require the MTF to register its facility and the types of SUDs they reprocess with the FDA. More information on this can be found at the FDA's Center for Devices and Radiological Health (CDRH) website: http://www.fda.gov/cdrh/reuse/index.html. MTFs can increase their use of durable linens and laundry services rather than using disposable gowns and linens. For MTFs that have a cafeteria, using reusable cloth napkins, trays, and silverware instead of disposable food service items is a viable alternative.

c. Environmental Evaluation. The increased use of durable items will decrease the volume of RMW and MSW being generated. Depending on how these items are disposed, this can lead to a decreased burden on available landfill space, as well as a savings in raw materials for the production of new products.

d. Economic Evaluation. While the initial purchase of durable items is greater than that for disposable items, the life cycle cost is less than purchasing and discarding disposable items. Therefore, washing, sterilizing, and reusing a durable item as many times as possible is environmentally and economically desirable. To wash linens, the MTF should already have a contract in place or its own washing facilities, as it should already have sterilization equipment to use for durable metal instruments.

3.3 TREATMENT

While reducing the amount of RMW is no longer an option in the treatment stage, treating RMW in a way that reduces environmental impact fosters good neighbor policies and promotes environmental stewardship. Numerous methods of effective RMW treatment have been developed based on heat, chemical, and radiation technologies. Keeping abreast of these developing technologies that can conserve resources and/or reduce emissions supports the P2 ethic. However, cost always plays a significant role in the decision of which technology to use now and in the future. Table 11 summarizes the capital, and operation and management (O&M) costs associated with various RMW treatment alternatives for capacities less than 550 lb/hr. The following sections discuss the common methods of treatment used within the U.S. Army Medical Command: incineration, autoclaving, and contract disposal.

3.3.1 Incineration

Incineration is a heat technology that treats RMW using high temperatures in excess of 1,400°F to kill the microorganisms. This heat reduces the waste to ashes, or approximately 10% of the original volume, rendering it unrecognizable and inert. These ashes are usually disposed as a solid waste in a municipal landfill.

A few problems are associated with this form of treatment. One is the possibility of the ash being a HW due to the concentration of metals, typically chromium and lead found in the waste stream. Additionally, due to pending incinerator air emission regulations, many operational incinerators may require expensive upgrades in the future to maintain regulatory compliance. There are also certain design limitations common to incinerators (e.g., the effects of high heat from burning extremely dry wastes such as paper or quenching effects from liquid wastes) that can reduce the operational life or increase the maintenance costs. All of these problems and their related costs vary with waste load and incinerator type; therefore, extensive investigation must be conducted prior to the selection of an incineration process. Ideally, an energy recovery system should be employed to capture the energy from the burning waste for reuse at the facility.

3.3.2 Autoclaving

Autoclaving is the tried and proven method of RMW treatment. Most U.S. Army medical facilities that are not using private contractors are using autoclaves to treat the RMW. An autoclave uses high-pressure steam to bake the waste, raising the temperature to a level sufficient to kill the microorganisms. After the RMW is treated, the waste no longer exhibits an infectious nature; therefore, it can be disposed of as a solid waste. There are four variations of the end disposal: direct landfilling, shredding/grinding, high-ratio compacting, and energy recovery.

- In direct landfilling, the treated RMW, now a general solid waste, is taken to a municipal landfill. There are no P2 opportunities associated with direct landfilling.
- With a shredding/grinding process, the waste is sent from the autoclave into a hammer mill that shreds the waste into confetti. The shredding reduces the volume by 85%, conserving landfill space, and renders it unrecognizable (as required by many State regulatory agencies). Sharps that are treated in an autoclave can be sent through a small sharps grinder and also disposed of as a solid waste.
- If RMW (minus sharps) is not required by local or State regulation to be rendered unrecognizable, using a general solid waste high-ratio compaction process is optimum. This process can reduce not only the treated RMW volume, but can also reduce the volume of all solid waste leaving the facility by 80%, thus making the transportation cheaper and minimizing the volume requiring landfilling. Based on environmental impact, cost and maintenance issues, high-ratio compaction of all of the MTF's solid waste is the ideal P2 initiative for RMW.
- A MTF may also consider coordinating with a local waste to energy plant in lieu of landfill disposal as the primary method of final disposition. While no cost benefit is derived from this practice, it reduces waste to the environment and provides a viable energy source.

3.3.3 Contract Disposal

While contract disposal of RMW is not considered a P2 initiative, it is included for comparison purposes. Without the use of the incinerator or other type of treatment technology, RMW disposal costs are generally calculated by weight, roughly $0.30/lb. The amounts of general solid waste and disposables placed in the RMW stream can significantly affect the overall disposal costs. Contracting avoids most of the maintenance and labor costs associated with RMW treatment but, depending on the contractor, may or may not be beneficial to the environment. Potential contractors should be scrutinized prior to awarding of the contract.

Table 11: Cost Summaries of RMW Treatment Alternatives

Alternative	Company	Capacity	Capital Cost	O&M Cost
Autoclave w/Shredder	Biomedical Waste Systems	500 lb/hr	$400,000	$48,314
Autoclave w/High Ratio Compactor	SAN-I-PAK	320 lb/hr	$250,000	$46,362
Autoclave w/Shredder	R.E.Baker	200 lb/hr	$188,500	$50,687
Thermal Reduction System	Empire International Corporation	500 lb/hr	$504,500	$38,527
Autoclave	Bondtech Treatment Technology	500 lb/hr	$209,269	$10,463
Chemical/Mechanical	Medical Safetec	416 lb/hr	$241,500	$40,498
Microwave	ABB Sanitec	550 lb/hr	$570,000	$32,215
Microwave	ABB Sanitec	350 lb/hr	$383,000	$32,215
Pyrolysis	Eshland Bio-Oxidizer Technology	150 lb/hr	$480,000	$64,997

CHAPTER 4 - SOLID WASTE

4.1 DESCRIPTION

Solid waste (also known as municipal solid waste, MSW) describes all items that are commonly disposed of in general trash. Components of MSW typically include food waste, paper and packaging, glass, metal, and plastics. MSW is generated throughout all facilities and activities within an MTF, ranging from administrative offices and patient treatment and recovery areas, to laboratories and cafeterias. Options to aid in the reduction of solid waste generated discussed here include recycling, which removes recoverable materials from the solid waste stream, and affirmative procurement, which requires the purchase of products made from these recovered materials, thus closing the “recycling loop” by providing a demand for these recovered materials and encouraging further recycling efforts.

4.2 RECYCLING

a. Description. Recycling involves segregating certain materials from the MSW stream prior to disposal so that those materials can be reused in an effort to conserve natural resources. Recyclable MSW includes white paper, mixed office paper, computer paper, newsprint, glass, plastic, metals (including aluminum, brass, copper, steel), yard waste, food waste, packing materials, and wood.

b. Technical Evaluation. Generally, 80% of the solid waste generated by the MTF is MSW. The MTF MSW stream consists of approximately 45% paper and cardboard, 15% plastics, 10% metals, 7% glass, 3% wood, 10% food wastes, and 10% other wastes. Most of these wastes could be segregated from the solid waste stream and recycled.

c. Environmental Evaluation. Recycling would reduce the amount of waste buried in a solid waste landfill. The current DOD "Non-Hazardous Solid Waste Diversion Rate" Measure of Merit requires that by the end of fiscal year 2005 (FY 05), the diversion rate for non-hazardous solid waste is greater than 40%. Although this is an installation requirement, the MTF could significantly reduce its MSW stream through increased segregation and recycling, which would result in a noticeable waste reduction/increased diversion rate for the associated installation. For example, estimate that the MTF generates 500 tons of MSW annually; 45% of this amount, 225 tons, is paper and cardboard. Assuming 90% of the paper and cardboard is recyclable, the MTF could remove 202.5 tons per year from its waste stream through segregation and recycling. Using the same assumptions (90% of the wastes are recyclable), Table 12 shows additional waste reduction estimates for the other waste classifications.

d. Economic Evaluation. MSW disposal costs approximately $0.025 per pound (or $50/ton). The estimated market rate for recyclable items is $0.052 per pound (or $104/ton). Assuming that the MTF would receive 25% of this value (which is minus fees charged by the recycler for handling the recyclables), the MTF would receive $0.013 per pound (or $26/ton). Using these figures, the disposal cost avoidance (amount saved by segregating recyclable items from solid waste) and the recyclable sales return (amount received from sale of recyclable items) are calculated for each recyclable waste classification. Table 12 shows these results.

Table 12: Recycling Solid Waste

Waste Classification	Solid Waste Percentage	Amount Generated (tons/yr)	Recyclable Amount (assumed 90%) (tons/yr)	Waste Disposal Cost Avoidance ($/yr)	Recyclable Sales Return ($/yr)
Paper and Cardboard	45	225	202.5	$10,125	$5,265
Plastics	15	75	67.5	$3,375	$1,755
Metals	10	50	45	$2,250	$1,170
Glass	7	35	31.5	$1,575	$819
Wood	3	15	13.5	$675	$351
Food Wastes	10	50	45	$2,250	$1,170
Other Wastes (Styrofoam, Rubber, etc.)	10	50	45	$2,250	$1,170
Totals	100	500	450	$22,500	$11,700

i. <u>Implementation Cost</u>. Collection containers would be required for paper, glass, plastic, and metals. If the recycler is not able to provide containers, then the MTF would incur procurement costs for the required containers.

ii. <u>Recurring Costs</u>. The recycler should manage recurring costs for this program to include labor costs, transportation costs, and equipment/maintenance costs. Profits received from the sale of recyclable items should be utilized to pay recurring costs for this program.

iii. <u>Recurring Cost Savings</u>. Increased waste segregation and recycling will result in volume reductions, reduced disposal costs, and noticeable revenues. For example, if the MTF removed the full amount of recyclable paper, cardboard, plastic, and glass from the waste stream, it would save $15,075 in disposal costs, divert 301.5 tons of waste from the landfill, and receive $7,839 from the recycler annually.

Avoided Disposal Costs:
$10,125/yr paper&cardboard + $3,375/yr plastic + $1,575/yr glass = $15,075/yr

Volume Recycled:
202.5 tons/yr paper&cardboard + 67.5 tons/yr plastic + 31.5 tons/yr glass = 301.5 tons/yr

Revenue Received:
$5,265/yr paper&cardboard + $1,755/yr plastic + $819/yr glass = $7,839/yr

Estimated volume reductions (Recyclable Amounts) and reduced disposal costs (Waste Disposal Cost Avoidance) are shown in the fourth and fifth columns of Table 12.

iv. Payback Period. The payback period for this P2 initiative will vary depending on the types and amounts of recyclable items collected by MTF personnel, and any implementation and recurring costs that the MTF may incur that are not covered by the recycler. Volume reduction and disposal cost avoidances will occur immediately as wastes are segregated for recycling. Revenues received will depend on current market rates.

4.3 AFFIRMATIVE PROCUREMENT (AP)

Affirmative Procurement (AP) refers to the Federal Government's "Buy Recycled" program and was first introduced in the RCRA of 1976. The objective of the AP program is to use the purchasing power of the Federal Government to stimulate recycling markets that sustain national recycling efforts. Purchasing products made with recycled materials increases the demand for those products, advances the technology used to manufacture them, and stimulates recycling programs.

Federal agencies using appropriated funds to purchase United States Environmental Protection Agency (EPA) designated items must establish procurement programs to allow the use of recovered materials to the maximum extent possible. There are currently approximately 54 designated items in 8 categories, many of which are purchased by MTFs. Some items include paper and paper products, cement and concrete, carpet, floor tiles, fiberboard, plastic desktop accessories, binders, toner cartridges, trash bags, and pallets. The current list of these items, as well as several items under consideration for inclusion, is provided in Figure 1 below.

MTFs should take the appropriate steps to establish the required AP programs. The requirement to purchase items with recycled content applies when the procuring agencies spend at least $10,000 per year on the designated item. A procuring agency is any Federal agency or contractor using appropriated Federal funds for the procurement. The $10,000 threshold applies to the entire agency such as the DOD. Since the MTFs belong to the DOD, the procurement guidelines apply.

AP purchases are a key component of integrated solid waste management. Buying recycled content products completes the recycling circle by creating a market for the recycled items. However, there are exceptions that may apply. The product must be available at a reasonable price, it must meet reasonable performance standards, and it must be available within a reasonable timeframe or at a sufficient level of competition.

When establishing procurement programs, all MTF purchasing activities, especially Government credit card holders, should be made aware of and expected to follow environmentally preferable buying practices.

The MTFs should also expand their environmentally preferable buying practices (EPP). EPP is defined as the act of purchasing products/services whose environmental impacts have been considered and found to be less damaging to the environment and human health when compared to competing products and services. Some examples include: procuring materials with less packaging, purchasing materials that are recyclable, purchasing items that are reusable, and substituting items that do not require HW disposal.

Figure 1: Comprehensive Procurement Guideline Items (* entries are proposed CPG IV items)

Paper and Paper Products
Commercial/Industrial sanitary tissue
Miscellaneous papers
Newsprint
Paperboard and packaging
Printing and writing papers

Construction Products
Building insulation products
Carpet
Cement and concrete
Latex paint
Floor tiles
Laminated paperboard
Patio blocks
Shower and restroom dividers/partitions
Structural fiberboard
Carpet cushion
Flowable fill
Railroad grade crossings/surfaces
Cement and concrete containing cenospheres*
Cement and concrete containing silica fume*
Modular threshold ramps*
Nonpressure pipe*
Nylon carpet and nylon carpet backing*
Roofing materials*

Transportation Products
Channelizers
Delineators
Flexible delineators
Parking stops
Traffic barricades
Traffic cones

Park and Recreation Products
Plastic fencing
Playground surfaces
Running tracks
Park and recreational furniture
Playground equipment

Non-Paper Office Products
Binders (paper, plastic)
Office recycling containers
Office waste receptacles
Plastic desktop accessories
Plastic envelopes
Plastic trash bags
Printer ribbons
Toner cartridges
Plastic binders
Plastic clipboards
Plastic clip portfolios
Plastic file folders
Plastic presentation folders
Office furniture*

Landscaping Products
Garden and soaker hoses
Hydraulic mulch
Lawn and garden edging
Yard trimmings compost
Food waste compost
Landscaping timbers and posts

Vehicular Products
Engine coolants
Re-refined lubricating oils
Retread tires
Tires*
Rebuilt vehicular parts*

Miscellaneous Products
Pallets
Sorbents
Awards and plaques
Industrial drums
Mats
Signage
Strapping and stretch wrap
Bike racks*
Blasting grit*

Potential P2 Initiative – Implement an Affirmative Procurement Program

a. Description. In an effort to strengthen post-consumer markets and comply with RCRA, MTFs should develop an AP program. The MTFs should ensure the following elements are contained within the AP program:

- Educate procurement personnel and credit card holders on the requirements and opportunities for AP and environmentally preferable purchasing;
- Develop policies and practices for ensuring all MTF contracts comply with the Federal Acquisition Regulations (FARs) AP requirements;
- Develop and implement policies for the systematic evaluation of purchasing practices;
- Create mechanisms for sharing AP information among MTF offices;
- Develop a tracking system for AP purchases when guidance becomes available from the Office of the Federal Environmental Executive and DOD.

b. Technical Evaluation. The implementation of an AP program must be a team effort, involving several functional areas. Primary responsibilities lie with purchasing, contracting, and logistics divisions and may include modifications to ordering and supply processes, contract preparation and execution, and evaluation of current standards and practices. The process must begin with raising awareness and educating purchasers and contract personnel.

c. Environmental Evaluation. AP programs stimulate recycling on an economic level. Creating a demand for recycled materials provides incentive for industries to utilize recycled products in their manufacturing processes. The result is that more recyclable materials are diverted from landfills or incinerators and are instead remanufactured into usable materials. Another environmental benefit is the conservation of both natural resources and energy used in the manufacturing process.

d. Economic Evaluation. Implementing an AP program will have some initial costs (primarily labor) and may never provide appreciable long-term economic benefits. Although there are published success stories in which the substitution of a recycled-content product saved money, in most cases the cost of a recycled-content product is fairly comparable to that of its virgin material counterpart. The true benefits of AP are related to compliance and stimulation of recycling markets, rather than lowering procurement expenditures.

i. Implementation Costs. The development of an AP program will not require capital investment; however, the primary cost includes the labor required to develop and implement the program. This is best performed by a team with participants from contracting, logistics, and other MTF divisions as appropriate. Assuming the program takes 1 year to fully implement, the labor costs are estimated to total $16,328. The labor costs are broken down as follows:

> *AP Program Lead*. The AP program lead will serve as chairperson of the AP committee or team. The program lead will document the goals and objectives of the team, track the team's progress, establish a formal policy for AP, and report to the commander on the progress of AP implementation.

Program Lead: 180 hours x $32 per hour = $5,760

General Training. All MTF purchasers, including credit card holders, supply personnel, office assistants, and contracting personnel, will require training on AP procedures. Such training is offered by USACHPPM, through other sources, or may be developed in-house. A cost of $5,000 is estimated to cover a one-time training event. Credit card holders may be given AP training with their regular credit card training (see below).

Contracting. Contracting personnel will provide training to contracting specialists and credit card holders on the AP requirements, modify contracts to include appropriate AP clauses, and review contracts to ensure compliance. All contracts specifying the use of Comprehensive Procurement Guidelines (CPG) items must contain required clauses for consideration of recovered materials. Credit card training will be conducted when cards are issued and then on a recurring basis. Assume training occurs 8 times per year for 1 hour.

Develop training:	20 hours x $32 per hour =	$640
Provide training:	8 hours x $32 per hour =	$256
Modify contracts:	30 hours x $32 per hour =	$960
Review contracts:	16 hours x $32 per hour =	$512
	Total	= $2,368

Logistics. Logistics personnel will make changes to the ordering/supply system to include identification and purchase of recycled-content products. Purchase orders, requisitions, and supply contracts must be modified and reviewed to ensure compliance with AP requirements.

100 hours x $32 per hour = $3,200

Total Implementation Costs = $5,760 + $5,000 + $2,368 + $3,200 = $16,328

ii. Recurring Costs. The only recurring cost associated with an AP program is the continuation of awareness training, particularly for credit card holders. Because AP requirements are easily integrated into existing training, there is no appreciable recurring cost. There may be future costs associated with reporting, which is required by Executive Order (EO) 13101. Neither the DOD nor the Army has issued guidance on implementing a reporting system to track AP purchases and monitor compliance. To date, DOD proposed reporting systems do not place a heavy burden on the purchaser or credit card holder. Rather, the proposed systems are automated or built-in to existing forms and systems.

iii. Recurring Cost Savings. There are no measurable cost savings to implementing an AP program. The purchase of specific recycled-content products may prove economically advantageous; however, this may not always be the case.

iv. Payback Period. Because there is no specific recurring cost savings to offset the implementation costs, there is no calculated payback period. As described above, the true benefits of AP are related to compliance and stimulation of recycling markets, rather than lowering procurement expenditures.

CHAPTER 5 - AIR POLLUTION

5.1 DESCRIPTION

Sources at an MTF that can contribute to air pollution include certain equipment or procedures that emit gases or fumes during sterilization and/or disinfection (e.g., ethylene oxide, glutaraldehyde), as well as potential leaks of ozone depleting chemical (ODC) containing equipment, such as refrigerators/freezers (possibly located in laboratories for storing samples and reagents, or in a cafeteria for food storage), window air conditioners, building chillers, ice machines, refrigerated centrifuges, and halon fire suppression systems.

5.2 STERILIZATION – ETHYLENE OXIDE

Ethylene oxide (EtO) is typically used to sterilize surgical instruments. Waste gases emitted by the EtO sterilizers contain EtO. Ethylene oxide is an extremely volatile, flammable liquid with a vapor that forms explosive mixtures with air over a wide range of concentrations (3 to 100% in air by volume). In addition, EtO is a known carcinogen, and can also have mutagenic and teratogenic effects on humans. EtO is the most commonly used gas sterilant due to its ability to penetrate long narrow openings of medical devices such as scopes, dialysis equipment, and plastic prostheses. The EtO sterilization process consists of exposing the instruments to heated EtO, which is very effective at destroying bacteria and viruses. The instruments are then aerated (vented to the atmosphere) for at least 8 hours to fully remove excess EtO. The potential for inhalation exposure exists when MTF workers open the sterilization chamber to remove equipment. Since exposure to EtO is a significant health concern, such sterilization systems require constant indoor air monitoring. Engineering and administrative controls, to include ventilation systems, written work practices, emergency procedures, environmental sampling, and real-time monitoring must be employed to prevent worker exposures and environmental releases.

5.2.1 Potential P2 Initiative – Equipment Replacement: Hydrogen Peroxide Gas Plasma Sterilization (STERRAD®)

a. Description. Hydrogen peroxide gas plasma sterilization systems, such as STERRAD, are a P2 alternative to the EtO process. This process operates by injecting hydrogen peroxide into a sterilization chamber through a self-contained cartridge. The hydrogen peroxide vaporizes and diffuses throughout the chamber in a deep vacuum. Energy is then applied, creating low-temperature plasma that destroys any microorganisms on the equipment.

b. Technical Evaluation. The entire gas plasma sterilization process takes only 75 minutes (as opposed to approximately 12 hours for EtO sterilization), allowing for more equipment to be sterilized over the same amount of time. The major disadvantage to gas plasma sterilization is that it is currently not effective in sterilizing equipment with long narrow tubing such as endoscopes. As a result, any MTF employing gas plasma sterilization would have to clean endoscopic tubes by an alternative sterilization method. One such method would be to soak the tubes in an aldehyde-based sterilization solution (either a manual or automated sterilization

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process) or use an automated peracetic acid sterilization system (see Section 5.2.2 below), by maintaining at least one EtO sterilization unit to sterilize this equipment, This particular equipment could also be sent to an outside contractor for sterilization by EtO.

c. Environmental Evaluation. Unlike EtO sterilizer waste emissions, gas plasma sterilization emissions contain primarily oxygen and water vapor, which are harmless and, therefore, do not require abators, monitoring, alarms, or personnel protective equipment. In addition, gas plasma sterilizers eliminate the need for 88 to 100% EtO, which is flammable and dangerous to store/handle prior to the sterilization process.

d. Economic Evaluation. Table 13 provides a cost comparison between the STERRAD gas plasma system and the EtO system. Figures in the table were used to calculate the recurring cost and recurring cost savings listed below.

Table 13: Comparison of Systems

	STERRAD	EtO
Number of Cycles Run per Year	624	312
OPERATING ITEMS		
Pouches/Wraps (peel packs)	$914	$2,008
Biological Test Indicators	$1,596	$11,138
Biological Indicator Reagents	$517	$0
Chemical Indicators	$58	$130
Tape	$252	$42
Sterile Water	$0	$15
Tamper Evident Arrows	$0	$589
Sterilant (cartridges/cassettes)	$4,992	$12,896
TOTALS PER YEAR		
Annual Recurring Cost	$8,329	$26,818
Annual Cost per Cycle	$13	$86

Cost Comparison Calculations
STERRAD Estimates:

Cycles: 2 cycles/day x 6 days/wk x 52 wk/year = 624 cycles/yr

Sterilant: $400/box x 1 box/5 cartridges x 1 cartridge/10 cycles x 624 cycles/yr = $4,992/yr

Tamper Evident Arrows: Not required for this device

Peel Packs: $152.37/case x 1 case/2 months x 12 months/yr = $914/yr

Tape: $21/roll x 1 roll/month x 12 months/yr = $252/yr

Biological Test Indicator: $399/box x 1 box/3 months x 12 months/yr = $1,596/yr

Biological Indicator Reagent: $99.50/box x 1 box/10 wk x 52 wk/yr = $517/yr

Chemical Indicator: $58.25/box x 1 box/yr = $58.25/yr

Pouches/Wraps: Not required for this device

Sterile Water: Not required for this device

Total Recurring Costs: $4,992 + $914 + $252 + $1,596 + $517 + $58.25 = $8,329/yr

Cost Per Cycle: $8,330/yr x 1 yr/624 cycles = $13.35/cycle

Cost Comparison Calculations
EtO Sterilizer Estimates:

Cycles: 1 cycle/day x 6 days/wk x 52 wk/year = 312 cycles/yr

Sterilant: $496/box x 1 box/12 cartridges x 1 cartridge/1 cycle x 312 cycles/yr = $12,896/yr

Tamper Evident Arrows: $34/box x 1 box/3 wk x 52 wk/yr = $589/yr

Peel Packs: Not required for this device

Tape: $21/roll x 1 roll/6 months x 12 months/yr = $42/yr

Biological Test Indicator: $459/box x 1 box/15 days x 7 days/wk x 52 wk/yr = $11,138/yr

Biological Indicator Reagent: Not required for this device

Chemical Indicator: $30/box x 1 box/12 wk x 52 wk/yr = $130/yr

Pouches/Wraps: $12.87/box x 1 box/50 pouches x 25 pouches/cycle x 312 cycle/yr = $2,008/yr

Sterile Water: $0.57/bottle x 1 bottle/2 wk x 52 wk/yr = $15/yr

Total Recurring Costs: $12,896 + $589 + $42 + $11,138 + $130 + $2,008 + $15 = $26,818/yr

Cost Per Cycle: $26,818/yr x 1 yr/312 cycles = $86/cycle

i. Implementation Cost. The cost to procure and install a single STERRAD unit is approximately $108,000, which includes the purchase of STERRAD Pans (instrument sets).

ii. Recurring Costs. As shown in Table 13, the annual recurring operational cost of one STERRAD unit is approximately $8,329. The STERRAD operates at approximately $13 per cycle.

iii. Recurring Cost Savings. The annual recurring cost of operating one EtO sterilizer is approximately $26,818. One EtO sterilizer operates at approximately $86/cycle. The recurring cost savings would be realized from no longer having to operate the EtO sterilizer.

iv. Payback Period. The payback period is calculated by dividing the implementation costs by the difference between the recurring cost savings and the recurring costs.

$$\frac{\$108{,}000}{(\$26{,}818/\text{yr} - \$8{,}329/\text{yr})} = 5.8 \text{ yr}$$

5.2.2 Potential P2 Initiative – Equipment Replacement: Peracetic Acid Sterilization (STERIS®)

a. Description. Instead of sterilizing items that can't be processed in the STERRAD system, such as endoscopes, with an aldehyde-based sterilant (glutaraldehyde), the MTF should switch to a nonglutaraldehyde-based sterilant. The automated STERIS system described below utilizes peracetic acid as the sterilant, and can be used for narrow opening equipment such as the endoscopes.

b. Technical Evaluation. Peracetic acid sterilization units use a 35% peracetic acid dry powder mixture that is diluted with water to a 0.2% peracetic acid concentration. The sterilization has a relatively short cycle time of approximately 30 minutes compared to the approximate 10-hour exposure to a 2% glutaraldehyde solution for cold sterilization of materials. Peracetic acid must be used in combination with anticorrosive additives. This system must also be monitored for sterility with live spores. These devices may only be used for equipment that can be completely submerged in the acidic solution, and only one scope or a few instruments can be processed at a time.

c. Environmental Evaluation. The sterilizing solution has a pH of 6.4 and is noncorrosive to metals. Additionally, the sterilization cycle has the advantage of no toxic emissions and the unit flushes the sterile water rinse to the sanitary sewer.

d. Economic Evaluation.

i. Implementation Cost. The cost to procure and install a single STERIS unit is approximately $16,000.

ii. Recurring Costs. Recurring costs are incurred from the materials that go into running and maintaining the peracetic acid sterilizer. The following estimates are based on running the system 2 times per day, 6 days per week for 52 weeks out of the year, with one batch run once per week for quality control (QC) purposes. Actual number of cycles run and QC performed will vary by MTF and per manufacturer's recommendations.

(2 cycles/day x 6 days/wk x 52 wk/yr) + (1 qc cycle/wk x 52 wk/yr) = 676 total cycles/yr

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Peracetic Acid (STERIS 20 sterilant concentrate) – 20 cartridges/case at a cost of $125/case (one cartridge used per sterilization cycle).

676 total cycles/yr x 1 cartridge/cycle x $125/20 cartridges = $4,225/yr

Biological Indicator – 40 indicators/case at a cost of $123/case (used once per week for QC cycle)

1 QC cycle/wk x 52 wk/yr x 1 indicator/cycle x $123/40 indicators) = $160/yr

Chemical Indicator – 200 indicator strips/case at a cost of $143/case (run one with each cycle)

676 total cycles/yr x 1 indicator/cycle x $143/200 indicator strips = $483/yr

Water – water passes thru a series of filters before rinsing instruments in sterilizer (approximately 4 gallons/cycle). Estimate cost to be negligible.

Depending on input water quality, filters for rinse water will need to be changed out on a regular basis.

"A" Filter – change once about every 3 months at a cost of $61/filter

1 filter/3 months x 12 months/yr x $61/filter = $244/yr

"B" Filter – change once about every 6 months at a cost of $118/filter

1 filter/6 months x 12 months/yr x $118/filter = $236/yr

Final Water Filter – change once about every 6 months at a cost of $139/filter

1 filter/6 months x 12 months/yr x $139/filter = $278/yr

Total Recurring Costs = $4,225/yr + $160/yr + $483/yr + $244/yr + $236/yr + $278/yr = $5,626/yr

Cost Per Cycle: $5,626/yr x 1 yr/676 cycles = $8.32/cycle

iii <u>Recurring Cost Savings</u>. Using the same data above in Section 5.2.1, the cost savings would be realized from no longer having to run an EtO sterilizer at a cost of approximately $26,818/yr.

iv. <u>Payback Period</u>. The payback period is calculated by dividing the implementation costs by the difference between the recurring cost savings and the recurring costs.

$$\frac{\$16{,}000}{(\$26{,}818/\text{yr} - \$5{,}626/\text{yr})} = 0.8 \text{ yr}$$

Alternatively, combining initiative 5.2.1 and 5.2.2 (i.e., replacing one EtO sterilizer with one hydrogen peroxide gas plasma sterilizer and one peracetic acid sterilizer together, instead of individually, as both instruments will be required as replacement sterilization units for all of the types of instruments sterilized by the EtO sterilizer), the payback period would be:

$$\frac{(\$108{,}000 + \$16{,}000)}{\$26{,}818/\text{yr} - (\$8{,}329/\text{yr} + \$5{,}626/\text{yr})} = 9.6 \text{ yr}$$

5.3 STERILIZATION – GLUTARALDEHYDE

Glutaraldehyde is used as a cold sterilant to disinfect and clean heat-sensitive equipment such as dialysis instruments, surgical instruments, suction bottles, bronchoscopes, endoscopes, and ear, nose, and throat instruments. Unlike EtO, glutaraldehyde is not a human carcinogen, however it is a toxic chemical that can cause severe irritation of the eyes, nose, throat, lungs, nausea, headaches, drowsiness, and dizziness. It can cause difficult breathing and other severe allergic reactions in workers who have become sensitized to it.

Potential P2 Initiative – Material Replacement

a. Description. Replacing a glutaraldehyde-based sterilant used in manual (soaking) sterilization or high level disinfection is an easy initiative to implement, as there are several FDA approved substitutes on the market. See the list "FDA-Cleared Sterilants and High Level Disinfectants with General Claims for Processing Reusable Medical and Dental Devices" (available at http://www.fda.gov/cdrh/ode/germlab.html, taking care to note which contain glutaraldehyde as the active ingredient and which do not. The performance of the substitute product should be evaluated to ensure satisfactory results before it is put in wide-scale use.

b. Technical Evaluation. Because this is a product substitution, there should be no major changes in the procedures utilized for product sterilization/high-level disinfection. In order to sterilize or disinfect correctly, the cold sterilization solutions must be used according to manufacturer's instructions. Normally, items totally immersed in cold sterilization solution for 10-20 minutes are considered disinfected, and after 10 hours are considered sterilized, but the time will vary by manufacturer and product. Most cold sterilizing solutions are effective for a specific period of time so that expiration dates need to be strictly adhered to (some manufacturers have test strips available to determine a solution's efficacy to aid in determining when the solution is no longer usable). Care should be taken to distinguish which replacement solutions are considered for disinfection and/or high-level sterilization (products such as Peract™ 20, Sporox™, and EndoSpor™ Plus), or may be considered for high-level disinfection only (such

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™ Sporox is a trademark name of Reckitt & Colman, Inc., Wayne, New Jersey.
™ EndoSpor Plus is a trademark of Cottrell Limited, Englewood, Colorado.

as Cidex OPA® and Sterilox™). Additionally, the automated peracetic acid sterilization system described in Section 5.2.2 is also considered an acceptable substitute for cold sterilization using glutaraldehyde-based solutions, but this is more than a product substitution as it also involves an equipment change.

c. Environmental Evaluation. While the substitute may no longer contain glutaraldehyde, it might contain certain constituents, or have physical characteristics (e.g., corrosivity, toxicity) that could require it to be handled as an HW when disposed. Substituting a new product may be a matter of replacing a more hazardous substance for a less hazardous substance. However, most of the substitute disinfectants/sterilants do not have the airborne toxic affects associated with the glutaraldehyde-based solutions. For example, Cidex OPA (approved for high-level sterilization only), whose active ingredient is 0.55% ortho-phthaldehyde, is considered an HW in California due to its toxicity, but may be treated with glycine to render it a non-HW (as long as local publicly owned treatment works and/or sewer agencies have been notified and have no prohibitions prior to disposal via the sanitary sewer).

d. Economic Evaluation. Because this is a direct product substitution initiative, no economic evaluation will be performed. In general, the non-glutaraldehyde-based solutions cost more than the glutaraldehyde-based solutions. However, there are ancillary benefits to substituting non-glutaraldehyde-based solutions. These include the need for special ventilation in the immediate work area, reduced personal protective equipment when working with the solutions, and reduction in personnel exposure to the toxic affects of glutaraldehyde and potential loss of work due to this exposure.

5.4 OZONE-DEPLETING CHEMICALS

Ozone-depleting chemicals are manmade compounds that represent a serious threat to the Earth's ozone layer. ODCs are stable, and when released they do not break down until exposed to the high radiation of the upper atmosphere. When this occurs they release chlorine or bromine, which react with ozone. This depletes the ozone layer, which protects humans and animals from harmful ultraviolet (UV) radiation. Chlorofluorocarbon (CFC) refrigerants, halons, and solvents (e.g., Carbon Tetrachloride, 1,1,1-Trichloroethane and Methyl Bromide) are the three categories of ODCs. The most common ODC refrigerant is R-12 (i.e., freon), which is used in air conditioners and refrigerators on most Army installations and MTFs. Halons are used exclusively as fire-fighting agents. Two possible P2 initiatives for ODC-containing equipment are eliminating the ODCs via attrition, and implementing an ODC leak detection program.

5.4.1 Potential P2 Initiative – Elimination of ODC Products Via Attrition

a. Description. The MTF should contact its host installation to see if they have already developed an installation-wide plan to eliminate their dependency on the commercial availability of Class I ODCs by the end of FY 03, as required in a 2002 Memorandum from the Assistant Secretary of the Army (Installations and Environment). Otherwise, the MTF should develop its

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own plan to eliminate their dependency on the commercial availability of Class I ODCs (through the reuse of recovered ODCs) or eliminate the use of Class I ODC products altogether via attrition. Developing a plan in this way allows older Air Conditioning and Refrigeration (AC&R) equipment that still has Class I refrigerant to be kept in service until the need arises for it to be repaired or replaced. At that time, the Class I refrigerant will be replaced with an appropriate substitute. The MTF should identify and prioritize equipment to retrofit, or otherwise retire and replace, in order to eliminate the majority of Class I ODCs in use at the MTF.

b. Technical Evaluation. This should be an easy initiative to implement, as replacement equipment with less potential for leakage, and which contains refrigerants which are either unclassified or Class II ODCs with much lower ozone depleting potential (ODP) than the Class I ODCs, are readily available. The Clean Air Act (CAA), section 612, requires the EPA to institute a program to identify alternatives to Class I (CFCs, halons, carbon tetrachloride, methyl chloroform, methyl bromide, and hydrobromofluorocarbons (HBFCs)) and Class II (hydrochlorofluorocarbon (HCFCs)) ozone-depleting chemicals and to publish lists of acceptable and unacceptable substitutes. The current list of substitutes is available through the EPA website at: http://www.epa.gov/ozone/snap/lists/index.html#refac.

c. Environmental Evaluation. While allowing for the continued use of Class I ODCs, implementing this initiative ensures that the equipment will eventually be replaced and the ODCs will be disposed of in an environmentally preferable manner. The Defense Logistics Agency (DLA) was assigned the mission of managing the Defense Reserve of Ozone Depleting Substances to ensure that the supplies for mission critical uses are available. DLA will provide central management for the receipt, storage and issuance through the Defense Supply Center Richmond (DSCR) which is the activity within DLA that manages these substances. This initiative also eliminates the purchase of new Class I ODCs. Additionally, the Army requirement for the elimination of the dependency on the commercial availability of Class I ODCs by the end of FY 03 predates the requirement established in EO 13148, were each agency is to phase out the procurement of Class I ODCs for all nonexcepted uses by December 31, 2006.

d. Economic Evaluation. An economic evaluation is not performed for this initiative because implementing the plan calls for the replacement of the ODC products when they need to be repaired or replaced. Thus, funds would have to be spent regardless if it were for replacing the old equipment with similar or the same item, or paying to replace it with non-Class I ODC containing equipment.

5.4.2 Potential P2 Initiative - Implement an ODC Leak Detection Program

a. Description. On 5 September 1995, the EPA issued a ruling that defined their refrigeration system leak repair guidelines in the Federal Register. These guidelines established maximum allowable leak rates for CFC AC&R equipment with capacities of 50 lb or more of refrigerant. In 28 May 1998, more stringent leak rates were proposed. The MTF's implementation of an ODC leak detection program would ensure compliance with 40 CFR 82.156, thus minimizing releases due to leaking and extending the working-life of the equipment. This CFR states that equipment leaking in excess of the above limits must be repaired within 30 days. This Good

Engineering Practice would require personnel to perform periodic checks on refrigeration equipment according to the schedule shown in Table 14.

Table 14: ODC Inspection Schedule Guidelines

Commercial refrigeration equipment	15% per year
Industrial process refrigeration equipment	20% per year
Comfort cooling and other appliances (existing)	10% per year
Comfort cooling and other appliances (new)	5% per year

b. Technical Evaluation. Because the MTF may contain several pieces of refrigeration equipment, it may not be feasible to implement a leak detection program for 100% of the equipment. However, it would be possible to prioritize the equipment in terms of equipment age and the amount of refrigerant it contains. For example, personnel could check each piece of equipment that is over 10 years old and each piece of equipment that contains more than a set amount of Class I refrigerant. A complete inventory of refrigeration equipment should be established for this purpose. Personnel could use this document to develop a prioritized list.

c. Environmental Evaluation. This initiative would reduce the amount of ODC entering the atmosphere. However, since any equipment currently leaking has not been identified, it is unknown how much of an impact this initiative will have.

d. Economic Evaluation. Since any leaking equipment has not yet been identified, a detailed economic analysis is not possible. The subsections below describe the various costs associated with this project in general terms.

i. Implementation Costs. This initiative is a change in current management practices that does not require any capital equipment to implement. As a result, it is not expected to have any initial implementation costs.

ii. Recurring Costs. The only recurring costs associated with this initiative would be for the labor required to check the equipment for leaks, and repair the leaks once discovered. Having personnel check the equipment in an area only when they visit the area for other routine maintenance services could reduce these costs. As a result, the personnel would not have to schedule specific trips to check equipment for leaks which will minimize costs associated with traveling to and from the various areas.

iii. Recurring Cost Savings. Recurring cost savings would result by preventing refrigerants from leaking into the atmosphere, thereby eliminating the need to buy replacement material. Once personnel begin to identify specific leaks, this cost savings can be quantified.

iv. Payback Period. The payback period is calculated by dividing the implementation costs by the difference between the recurring cost savings and the recurring costs. With this initiative having no implementation costs, an immediate payback period would be realized if the avoided cost of purchasing replacement refrigerant (recurring cost savings) is larger than the cost of the labor to identify and repair any leaks (recurring costs). Otherwise, implementing this initiative would ensure compliance with 40 CFR 82.156, but would not have a payback period.

CHAPTER 6 - UNIVERSAL WASTE

6.1 DESCRIPTION

On May 11, 1995 the EPA finalized its Universal Waste Rule. The new streamlined HW regulations govern the collection and management of certain widely generated wastes identified as universal wastes. The goal of the final rule is to separate universal waste from municipal waste stream. Under RCRA C regulations, the management of waste differs based on the waste's generating source. Waste generated by consumers in their homes or by conditionally exempt small quantity generators is not regulated under RCRA when discarded. Conversely, the same waste would be subject to regulation if generated by commercial establishments, industries, and other nonexempt generators. Universal wastes are wastes generated by both groups. Consequently, universal wastes that should go into an HW system may be entering MSW landfills from exempt generators. The EPA believes that the new universal waste rules will encourage exempt generators to handle their universal waste under these rules. Additionally, nonexempt HW generators no longer have to handle these wastes under full RCRA C regulations but rather the new streamlined rules. The universal rule covers wastes that go to either recycling or treatment facilities. The specifics of universal waste regulations can be found in 40 CFR 273. In States authorized by the EPA to operate their own HW programs (RCRA authorized States), the rule will not take effect until the particular State adopts the program.

The rule greatly reduces the regulatory burden to HW generators for sending their universal wastes to a collection facility. Universal wastes are exempt from the requirements of the RCRA (40 CFR 262-272); therefore, fluorescent lamps, batteries, pesticides, and mercury-containing thermostats are not included as HW in calculations of the quantity generated monthly at the facility. Because pesticides and thermostats are atypical hospital wastes, they will not be addressed in this guide.

6.2 FLUORESCENT LIGHT BULBS

According to EPA studies, many fluorescent lamps exhibit the toxicity characteristic for mercury and are therefore classified as an HW and must be managed as such. When disposed in municipal landfills, the mercury in the lamps has the potential to leach into the soil and ground water.

There are three potential disposal options for mercury-containing lamps, listed in descending order of preference; turn-in lamps for reclamation, turn-in for disposal, and treat the lamps onsite. One of these three methods should be utilized for management of fluorescent lamps and are discussed below. An alternative, replacing the lamps with “green” lamps, is also discussed to potentially eliminate this HW stream.

6.2.1 Potential P2 Initiative – Reclamation of Fluorescent Lamps

a. Description. The fluorescent lamps used at the MTF should be collected and managed for reclamation as a universal waste. This option is the preferred option for managing the current HW lamps. The offsite reclamation involves the removal of the phosphor powder, which also removes most of the heavy metals. The end products are glass, metal, and a phosphor/mercury mix.

b. Technical Evaluation. Universal waste laws regarding offsite transport of HW lamps destined for recycling have made this an extremely easy initiative to implement. These laws have eliminated many of the requirements for handling the used lamps as an HW, making it easy and economical to recycle. To implement this alternative and ensure that all lamps are collected and disposed of properly, the MTF would probably have to institute a centralized management point for lamps. This would best be accomplished through housekeeping or through the logistics division, whichever is responsible for changing the fluorescent lamps.

c. Environmental Evaluation. Assuming the MTF generates approximately 100 spent lamps per year, and that each lamp weighs approximately 0.50 lb, then managing the lamps as universal waste could potentially eliminate approximately 50 lb/yr of fluorescent lamps (100 lamps x 0.50 lb/lamp) as an HW. Although lamp recycling would not reduce the number of used lamps generated, it would reduce the number of lamps being disposed of as HW. This would help conserve HW landfill space as well as conserve resources since the recycled material from the lamps would be recovered and reused in the manufacture of other products. In addition, (under most State regulations) the used lamps would no longer have to be manifested as an HW since they will be collected for reuse, thus reducing administrative burden.

d. Economic Evaluation.

i. Implementation Cost. The most economic approach to implementing this initiative without incurring any additional costs is to integrate fluorescent lamp management into the host installation's HW operating functions.

ii. Recurring Costs. Recurring costs include labor costs for a coordinator/monitor and materials handling, assuming the transportation is provided by the contractor/recycler. At $25 per hour for 1 hour per week, the recurring cost is $25 per week or $1,300 per year ($25/wk x 52 wk/yr). However, the recycler may require that the generator pay for the recycling cost and transportation cost to the recycling facility. At an estimated recycling/transportation fee of $2.00/lb, this would cost a total of $100/yr ($2/lb x 50 lb/yr). The total recurring costs are therefore, $1,400/yr ($1,300/yr + $100/yr).

iii. Recurring Cost Savings. By not disposing of used lamps as an HW, the MTF would not have to pay the HW disposal fees. Estimating the disposal fee for the mercury lamps to be $1.50/lb, this would result in a cost savings of $75/yr ($1.50/lb x 50 lb/yr).

iv. Payback Period. Because the estimated recurring costs ($1,400) outweigh the estimated recurring cost savings ($75), this initiative would not have a payback period. However, note that there are noneconomic benefits to be realized from instituting this program, to include compliance with EO 13148 and other Federal, DOD and Army initiatives for recycling, conservation of natural resources, and environmental stewardship.

6.2.2 Disposal of Fluorescent Lamps

a. Description. The used fluorescent lamps should be collected and managed for disposal as an HW. This option typically costs approximately the same price as recycling the lamps and should only be considered if there are no available reclamation facilities. Spent fluorescent lamps cannot be disposed of in general trash because they usually fail the toxicity characteristic leaching procedure (TCLP) test for mercury, thus making them an HW when disposed.

b. Technical Evaluation. Since the majority of spent lamps exhibit the characteristic of mercury, the lamps should be managed as an HW. Generators should make this classification based upon their knowledge of the waste stream, rather than performing expensive analytical testing. To implement this alternative and ensure that all lamps are collected and disposed of properly, the MTF would probably have to institute a centralized management point for lamps. The logistics division or housekeeping could serve as the centralized point.

c. Environmental Evaluation. Managing the lamps for disposal as HW would not reduce the number of spent lamps generated, estimated here as 50 lb/yr, but would ensure the proper handling and final disposition of the lamps with applicable Federal and State laws, protecting the environment and the public from possible exposure.

d. Economic Evaluation.

i. Implementation Cost. The most economic approach to implementing this initiative without incurring any additional costs is to integrate fluorescent lamp management into host installation's HW operating functions.

ii. Recurring Costs. Recurring costs include labor costs for a coordinator/monitor and materials handling. At $25 per hour for 1 hour per week, the recurring cost is $25 per week or $1,300 per year. Additionally, the disposal contractor will require the generator to pay for the transportation and disposal costs. At an estimated disposal/transportation fee of $1.50 per pound, this would cost a total of $75/yr ($1.50/lb x 50 lb/yr). The total recurring costs are therefore $1,375/yr ($1,300/yr + $75/yr).

iii. Recurring Cost Savings. Because the host installation should currently be disposing of the spent fluorescent lamps as an HW, the recurring cost savings should be the same as the recurring costs as described above.

iv. Payback Period. Because the estimated recurring costs equal the recurring cost savings, this initiative would not have a payback period. However, note that there are non-economic benefits to be realized from this program, including proactive environmental stewardship, compliance with Federal, State, and local laws regarding the handling and disposal of HW, and the avoidance of possible penalties and fines for noncompliance with said laws.

6.2.3 Potential P2 Initiative – Onsite Treatment of Fluorescent Lamps

a. Description. This option would allow generators to crush the lamps on site, consolidate the mercury, and manage the remaining glass/metal as non-RCRA waste. Unfortunately, there may be some compliance issues associated with this practice, such as the potential need for a RCRA permit, land disposal restriction (LDR)-related problems, and industrial hygiene issues. For these reasons, it is recommended that if lamp-crushing is planned, the MTF should coordinate this operation with their installation environmental office.

b. Technical Evaluation. If the MTF decides to manage the lamps as universal waste, the lamps should not be crushed by the generator, as recyclers may charge up to twice as much to process broken lamps, or may refuse to accept them at all. If the lamps are to be managed as an HW and are to be crushed on site, operating permits may be required. Lamp crushing requires careful oversight and proper equipment to avoid the release of mercury. To implement this alternative and ensure that all lamps are collected and disposed of properly, the MTF would probably have to institute a centralized management point for lamps. This would best be accomplished through the logistics division or housekeeping.

c. Environmental Evaluation. Although lamp crushing would not reduce the number of used lamps generated, it would reduce the waste volume by approximately 80%, thus reducing packaging and transportation costs. The separated mercury would still have to be managed/disposed of as HW, while a TCLP test should be performed on the remaining glass/metal before determining if it could be recycled, disposed of as a solid waste, or disposed of as an HW.

d. Economic Evaluation.

i. Implementation Cost. Initial cost for this alternative would be the cost to purchase the lamp-crushing unit, estimated at $1,900.

ii. Recurring Costs. Recurring costs include labor costs for a coordinator/monitor and materials handling. At $25 per hour for 1 hour per week, the recurring cost is $25 per week or $1,300 per year. Additional recurring costs include filter replacements for the device, approximately $13 per year, and disposal costs for the crushed lamps (approximately 50 lb/yr) and filters (approximately 2 lb/yr).

> Assuming a worst-case scenario that both the filters and the crushed lamps will fail a TCLP test for mercury, HW disposal at $1.50/lb would be approximately $78/yr ($1.50/lb x (50 lb/yr + 2 lb/yr)). The total recurring costs are therefore, $1,391/yr ($1,300/yr + $13/yr + $78/yr).
>
> Assuming a best-case scenario, only the filters would have to be disposed of as an HW, for a cost of $3/yr ($1.50 x 2 lb/yr). The remaining glass/metal could be disposed of as solid waste (assuming it passed a TCLP) for a negligible fee. The total recurring costs are therefore, $1,316/yr ($1,300/yr + $13/yr + $3/yr).

iii. Recurring Cost Savings. With the worst-case scenario, the installation would have no recurring cost savings because it would still be disposing of the crushed lamps as an HW. For the best-case scenario, the installation would avoid having to dispose of approximately 50 lb/yr of crushed lamps as an HW for a savings of \$75/yr (\$1.50/lb x 50 lb/yr).

iv. Payback Period. In the event that the crushed lamps still have to be disposed of as an HW, there would be no payback period because the implementation cost (\$1,900) and recurring costs (\$1,391/yr) far outweigh the recurring cost savings (\$0). For the scenario where the crushed lamps can be disposed of as a solid waste, the payback period is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

$$\frac{\$1{,}900}{\left(\$75/\text{yr} - \$1{,}316/\text{yr}\right)} = -1.5 \text{ yr}$$

Again, there would be no payback (as indicated by the negative result) because the implementation cost (\$1,900) and recurring costs (\$1,316/yr) are larger than the recurring cost savings (\$75/yr).

6.2.4 Potential P2 Initiative – Replace Fluorescent Lamps with Low-Mercury Design

a. Description. The establishment of the TCLP standard of 0.2 mg/L for mercury by the EPA made most fluorescent lamps an HW when they were to be disposed. Lamp manufacturers are now producing low-mercury (i.e., “green”) fluorescent lamps by reducing the amount of mercury in lamps to a level where they would pass the TCLP standard and would no longer exhibit an HW characteristic. The MTF could replace the current fluorescent lamps with the low-mercury versions, thus eliminating the lamps from the HW stream.

b. Technical Evaluation. This would be an easy initiative to implement. Several manufacturers now produce low-mercury fluorescent lamps that are comparable in wattage, energy efficiency, and average life as standard lamps. To distinguish low-mercury fluorescent lamps from standard lamps, the American manufacturers are using some type of green markings for identification (either green end-caps or green lettering). Note that foreign manufacturers may be using green markings on lamps, but the markings may not indicate low-mercury. Implementation of this initiative would involve purchasing the low-mercury lamps, replacing the standard lamps with the low-mercury lamps as they go out of service, and managing the two types of lamps separately for disposal until all of the standard lamps have been replaced with the low-mercury lamps. To ensure that all lamps are collected and disposed of properly, the MTF would probably have to institute a centralized management point for lamps. This would best be accomplished through the logistics division or housekeeping.

c. Environmental Evaluation. Although substitution with low-mercury lamps would not reduce the number of used lamps generated, it would reduce the costs and burdens associated with HW lamp disposal, such as higher disposal costs and manifesting. For this example, this initiative has the potential to divert approximately 50 lb/yr of fluorescent from the HW stream to the solid waste stream. Regardless of the brand of low-mercury lamp chosen to replace the standard lamps, it would be practical for the MTF to test the lamps with the TCLP to verify that they pass and can be exempt from HW regulations.

d. Economic Evaluation.

i. Implementation Cost. The most economic approach to implementing this initiative without incurring any additional personnel costs is to integrate fluorescent lamp management into the host installation's HW operating functions. The MTF should perform the TCLP on the low-mercury lamps to ensure they are exempt from HW regulations. Assume the cost of this test to be approximately $140.

ii. Recurring Costs. Recurring costs would be the costs for purchasing an estimated 100 low-mercury lamps per year, based on the estimate for this example that 100 lamps will need to be replaced per year. Estimating a purchase price of $1.32/lamp (based on General Services Administration (GSA) price for a package of 30 Philips Alto® (low mercury) 48-inch lamps) the total recurring costs would be $132/yr ($1.32/lamp x 100 lamps/yr). The disposal costs of the lamps as a solid waste is assumed to be negligible.

iii. Recurring Cost Savings. After the last of the standard lamps have been replaced, the MTF could avoid having to dispose of the low-mercury lamps as an HW. Assuming 100 lamps weigh approximately 50 lb, and the HW disposal cost for mercury is approximately $1.50/lb, the MTF would save $75/yr ($1.50/lb x 50 lb/yr). Additionally, the MTF would no longer be purchasing the standard lamps. Estimating a purchase price of $1.19/lamp (based on GSA price for a package of 30 Osram Sylvania 48-inch lamps) the cost savings would be $119/yr ($1.19/lamp x 100 lamps/yr). The total recurring cost savings would be $194/yr ($75/yr + $119/yr), after all of the standard lamps have been replaced and properly disposed.

iv. Payback Period. The payback period for this initiative is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

$$\frac{\$140}{(\$194/\text{yr} - \$132/\text{yr})} = 2.3 \text{ yr}$$

This initiative would pay for itself in approximately 2.3 years, after all of the standard lamps have been replaced and disposed of properly. Note that the MTF may want to continue to recycle the lamps after they have been replaced with the green tipped lamps. While the lamps now pass the TCLP and can be disposed of as a solid waste, they still contain some mercury that may eventually be released to the environment if landfilled.

® Alto is a registered trademark name of Royal Philips Electronics, Amsterdam, The Netherlands.

6.3 BATTERY MANAGEMENT

Potential P2 Initiative – Rechargeable Batteries

a. Description. MTF operations include the use of disposable alkaline batteries in a variety of equipment, to include, but not limited to, diagnostic devices, flashlights, pumps, and radio equipment. Rechargeable batteries should be used in such nonsensitive equipment, reducing the cost of procuring new batteries and the disposal of waste batteries considerably.

b. Technical Evaluation. Assume the MTF generates 20 spent alkaline batteries per month of various sizes (A, C, D, AA, AAA) for a variety of instruments (e.g., flashlights and medical equipment). Rechargeable alkaline batteries have an expected lifetime of up to 25 times that of a traditional nonrechargeable alkaline battery. Therefore, replacing nonrechargeable alkaline batteries with rechargeable alkaline batteries would result in a larger battery waste reduction for the MTF. To switch from nonrechargeable to rechargeable alkaline batteries, a complete inventory of required battery types would be required. Note, not all batteries may be replaced by rechargeable ones. Certain equipment may require special energy supplies to facilitate memory storage or reliability. To avoid equipment damage, information loss, and/or reduced reliability, reference the equipment manufacturer information and applicable safety criteria before changing battery types. At least two battery sets per device would be required to allow one set to charge while the other set is in use. Use the number of required batteries and their estimated recharging frequencies to determine the required number of battery recharging sets.

c. Environmental Evaluation. Utilizing rechargeable alkaline batteries could reduce the number of spent batteries by up to 96%. For example, if 20 nonrechargeable batteries last 1 month, then 480 batteries would be required to supply power for 2 years. Whereas, 20 rechargeable batteries would last the entire 2 years (24 recharges), reducing the waste stream by 460 batteries or 96%. Actual waste reduction will vary depending on sizes and weights of the nonrechargeable alkaline batteries in use.

$$\frac{460\,\text{reduced batteries}}{480\,\text{reduced batteries}} \text{ x } 100\% = 96\%\,\text{reduction}$$

d. Economic Evaluation.

i. Implementation Cost. The implementation cost for the MTF battery recycling program includes the purchase of fully rechargeable batteries and battery recharging units. Costs will vary depending on required manufactures and battery types.

Cost of Rechargeable Batteries:	AAA – 4/$5.00
	AA – 4/$5.00
	C – 2/$5.00
	D – 2/$5.00

Cost of Battery Recharging Unit:

$30 (recharge any combination up to 8 AAA, AA, C, or D cells at one time)
$15 (can recharge up to 4 AA or AAA cells at one time)

For this example, assume that the 20 spent batteries generated per month are 10 D-size batteries, 2 C-size batteries, and 8 AA-size batteries. Two of each battery will have to be purchased so that while one set is in use, the other set is recharging. The cost to purchase these 40 rechargeable batteries is $70 ($50 (for 20 D) + $10 (for 4 C) + $10 (for 8 AA)).

For this example, three recharging units will have to be purchased: two of the $30 units (for up to 8 AAA, AA, C, or D cells) and one of the $15 units (for up to 4 AA or AAA cells) for a total of $75.

Total Implementation Cost: $70 + $75 = $145

ii. Recurring Costs. Recurring costs for this program will include recyclable battery purchases (as the old ones are depleted) and disposal of the spent recyclable batteries.

Because there are two sets of batteries alternating in use, they should last for 4 years (24 recharges each, every other month). Dividing the purchase price of two new sets of rechargeable batteries over this time period would give a yearly recurring cost for the purchase of new batteries of $17.50/yr ($70/4 yr).

Similarly, both sets of batteries will have to be disposed of at the end of the 4-year period with an estimated disposal price of $0.82 per battery for a total cost of $32.80 (40 batteries x $0.82/battery). Dividing the recurring disposal cost over the 4-year time period gives a yearly disposal cost of $8.20/yr ($32.80/4 yr).

Total Recurring Costs: $17.50/yr + $8.20/yr = $25.70/yr

iii. Recurring Cost Savings. The recurring cost savings come from not having to purchase the equivalent number of nonrechargeable alkaline batteries and paying for their disposal over the same time period. Again, assume the MTF generates 20 used alkaline batteries per month, and the disposal cost per battery is approximately $0.82. The purchase prices for nonrechargeable alkaline batteries are listed below.

Cost of Nonrechargeable Batteries: AA – 4/$2.00
C – 6/$7.99
D – 12/$11.60

For a 1-year period, the MTF would have to purchase 240 nonrechargeable batteries ((10 D/month + 2 C/month + 8 AA/month) x 12 months/yr) for a total cost of $195.96/yr ((120 D/yr x $11.60/12) + (24 C/yr x $7.99/6) + (96 AA/yr x $2.00/4)).

Disposal for 240 batteries would be approximately \$196.80/yr (240 batteries/yr x \$0.82/battery).

Total Recurring Cost Savings: \$195.96/yr + \$196.80/yr = \$392.76/yr

iv. <u>Payback Period</u>. The payback period for this example initiative is calculated by dividing the implementation cost by the difference between the recurring cost savings and recurring costs.

$$\frac{\$145}{\left(\$392.76/\mathrm{yr} - \$25.70/\mathrm{yr}\right)} = 0.4 \text{ yr}$$

This initiative would pay for itself in approximately 0.4 years (approximately 5 months).

CHAPTER 7 - HAZARDOUS MATERIALS MANAGEMENT

7.1 DESCRIPTION

Minimization of hazardous material (HAZMAT) is an integral part of the Army goal to reduce HW. MTFs are encouraged to reduce, or altogether avoid, the use of HAZMAT and the subsequent generation of HW when those materials are no longer needed or otherwise disposed of within the activity. Two initiatives to aid in accomplishing this goal are the use of hazardous materials inventory controls and participation in a hazardous materials pharmacy.

7.2 INVENTORY CONTROLS

7.2.1 Limit Hazardous Material Use

Implement new systems, equipment, and maintenance procedures to minimize the use of HAZMAT. Procedures should be established to control HAZMAT by limiting their use to the maximum extent possible without adversely impacting patient care. The smallest amount of HAZMAT that is effective should be used to accomplish the mission. Activities should retain minimal quantities of HAZMAT to effectively support mission accomplishments.

7.2.2 Purchase Controls

Only those HAZMATs on the current inventory of items stocked or procured should be ordered through logistics activities. If this is not possible, coordinate the request through an appropriate committee for substitution. For example, a request for nonstocked cleaning supplies should be referred to the Infection Control Committee to determine if a suitable stocked item would satisfy the requirement. Validate that only needed materials are on hand/being purchased.

7.2.3 Product Substitution

Actively pursue the substitution of nonhazardous or less hazardous chemicals to replace HAZMAT. Product substitution is the most expedient method of reducing HAZMAT by substituting one material with another that can do the job equally well, but is less hazardous to workers and the environment.

7.2.4 Stock Rotation

Inspect stored HAZMATs routinely to verify that inventory is being rotated to ensure that older materials are used before new stock, thus avoiding disposal of HAZMAT as HW due to expired shelf-life.

7.3 HAZARDOUS MATERIALS PHARMACY

Preventing waste is the important first step in managing waste. One of the most effective methods for handling hazardous materials is the pharmacy concept, which establishes a single point of control and accountability over the requisitioning, receipt, distribution, issue, and reissue of hazardous materials. Under this system, hazardous materials are issued to users in a similar manner as medicines are dispensed in a pharmacy (i.e., on an as-needed basis). By whatever name these centers are called (e.g., HAZMAT Pharmacies (HAZMARTs), Hazardous Material Minimization Center (HAZMINCENs) or HAZMAT Control Centers), the system of centralizing the purchase and control of hazardous materials has saved installations millions of dollars and has kept tons of materials out of expensive HW landfills.

The host installation may already have some form of Hazardous Materials Pharmacy system operating in place, and the local MTF should be encouraged to participate in this program. If no (or a limited version) pharmacy program is available at the installation level, the MTF should consider developing and implementing its own, albeit on a smaller scale.

Traditionally on an installation, there have been several independent methods through which activities/tenants could order/acquire hazardous materials. Often there are no controls over the placement of requisitions. The Hazardous Materials Pharmacy concept is designed to improve control of HAZMAT. A HAZMAT Pharmacy oversees the purchase, use, and proper disposal of all hazardous materials on an installation. In a typical system, the pharmacy personnel will order, inspect, receive and catalog all hazardous materials. Once hazardous materials are received on an installation, they come under the control of the pharmacy. Pharmacies may either operate from a separate facility at which hazardous materials are stored and issued, or they may issue directly from installation supply (a “virtual” pharmacy). The pharmacy should maintain an Authorized Use List (AUL). An AUL is a list of hazardous materials approved for use at a certain location/activity to ensure that only trained personnel, in approved locations and for approved purposes, use them. The pharmacy should also maintain Material Safety Data Sheets (MSDS) in order to meet all reporting requirements, such as those mandated by the Emergency Planning & Community Right-to-Know Act (EPCRA) or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Most software systems for hazardous material management will automatically provide the appropriate reporting forms.

Materials are distributed to authorized users or processes on an as-needed basis, minimizing on-site storage requirements and allowing the installation to avoid the cost of over-purchasing materials. Users return leftover materials to the pharmacy where they are reinspected. Pharmacy personnel then make the decision whether to reissue the product to another user (at no cost to the user), to recycle remaining materials, or to properly dispose of them. Pharmacy personnel also rotate stock and evaluate any expired items to determine if its shelf-life can be extended. All of these practices reduce the amount of money spent on purchasing new products and disposing of used or expired ones. When items are recycled or disposed of, pharmacy personnel complete the appropriate paperwork related to their disposition. A bar coding system can be used to ensure that all materials can be tracked, located, and documented properly.

Primary motivating factors for implementing and maintaining a hazardous materials management program as described above include reductions in hazardous material purchasing and HW disposal costs, along with increased worker and environmental safety.

The pharmacy concept has been proven in terms of cost savings and waste reduction. The amount of unused HAZMAT turned into the DRMO has significantly decreased in the years since installations have implemented HAZMAT Pharmacies. The amount of HAZMAT disposed of as HW by the DRMS has been reduced by approximately 1.5 million pounds since 1995.

APPENDIX A - REFERENCES

Section I
Related References

Army Regulation (AR) 40-61, Medical Logistics Policies and Procedures, 25 January 1995.

Executive Order (EO) 13101, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, September 14, 1998.

EO 13148, Greening the Government Through Leadership In Environmental Management, April 22, 2000.

DOD 4160.21-M, Defense Materiel Disposition Manual, Chapter 11, Precious Metals Recovery Program, 18 August 1997.

Final Rule, Protection of Stratospheric Ozone: Supplemental Rule to Amend Leak Repair Provisions Under Section 608 of the Clean Air Act, Part III, Environmental Protection Agency, 60 Federal Register 40419 (60 FR 40419), 7 September 1995.

Title 42, U.S.C. §§6901 et seq. (1998), Resource Conservation and Recovery Act.

Title 40, Code of Federal Regulations (CFR), 2002 rev, Part 82, Protection of Stratospheric Ozone.

Title 40, CFR, 2002 rev, Part 261, Identification and Listing of Hazardous Waste.

Title 40, CFR, 2002 rev, Part 273, Standards for Universal Waste Management.

California Environmental Protection Agency, Department of Toxic Substances Control, Office of Pollution Prevention and Technology Development, *Pollution Prevention Guide for Hospitals (Excluding Medical Wastes)*, May 1998.

Classification of Waste Pharmaceuticals (Fact Sheet), U.S. Army Center for Health Promotion and Preventive Medicine, January 2003, prepared by Dominique Lowrance-Snyder.

Guide to Pollution Prevention: *Selected Hospital Waste Streams*, U.S. EPA, Center For Environmental Research Information, June 1990, EPA/625/7-90/009.

Headquarters, Air Force Center for Environmental Excellence, *Fact Sheet Hazardous Materials Pharmacy*, August 1994.

Latendresse, John R., Warbrittion, Alan R., Jonassen, Henning, and Creasy, Dianne M., *Fixation of Testes and Eyes Using a Modified Davidson's Fluid: Comparison with Bouin's Fluid and Conventional Davidson's Fluid*, Toxicological Pathology, vol 30, no 4, pp 524-533, 2002.

Memorandum, Acquisition and Technology Office of the Under Secretary of Defense, 13 May 1998, subject: New DoD Pollution Prevention Measure of Merit.

Memorandum, Assistant Secretary of the Army (Installations and Environment), 22 November 2002, subject: Elimination of Ozone-Depleting Chemicals (ODCs) in Army Facilities – ACTION MEMORANDUM.

Memorandum, Assistant Chief of Staff for Installation Management, 07 Jan 2003, subject: Change in Army Policy for the Elimination of Ozone Depleting Chemicals.

Pollution Prevention Opportunities at Medical Treatment Facilities, U.S. Army Center for Health Promotion and Preventive Medicine, August 1997, prepared by Eric Haukdal and 1LT Lisa Strutz.

Region 4 DoD Pollution Prevention Partnership, DRAFT *Best Management Practices Resource Guide, Chapter 2 – Hazardous Material Control Pharmacies*, November 2001.

Stone, K. R., *Veterans Affairs Hospital and Hospital Waste Minimization Case Studies*, Environmental Protection Agency, Cincinnati, Ohio. Risk Reduction Engineering Laboratory, May 1990.

Washington State Department of Ecology Waste Reduction, Recycling, and Litter Control Program, *Pollution Prevention In Hospitals and Medical Facilities*, June 1993, Publication No. 93-39.

The Waste-Paper, The Hazardous Waste Disposal Monthly Update, Princeton University, vol. 6, issue 10, October 2003.

Waste Reduction Resource Center, *DoD HAZMAT Control Pharmacies*.

Section II
Website References

Advanced Sterilization Products, maker of Cidex and STERRAD (http://www.sterrad.com/)

Army Ozone-Depleting Substance (ODS) Elimination Program (http://www.environmentalsupportoffice.com/ODC/ODC_XSummary.htm)

Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA (ALT)) Environmental Support Office (formerly the Army Acquisition Pollution Prevention Support Office (AAPPSO)) (http://www.environmentalsupportoffice.com/index.html)

B/R Instrument Corporation (http://www.brinstrument.com)

Canadian Silver Recovery Services, Inc. (http://www.csrs.com/csrsprod.finaltreatment.html)

CBG Biotech (http://www.cbgbiotech.com)

CMT Environmental Services, Inc. (http://cmt-enviro-serv.com/index.html)

Department of Defense Ozone Depleting Substances Reserve
(https://www.denix.osd.mil/denix/Public/News/DLA/ODS/odsres.html)

Eastman Kodak Company:
(http://www.kodak.com/US/en/motion/support/processing/h245/h24056.shtml)
(http://www.kodak.com/US/en/motion/support/processing/h245/h24057.shtml)
(http://www.kodak.com/US/en/motion/support/processing/h245/h24058.shtml)

FUJIFILM Medical Systems USA, Inc. (http://www.fujimed.com/medical/medical.html)

GE Medical Systems (http://www.gemedicalsystems.com)

General Services Administration (http://www.gsaadvantage.gov)

Headquarters, United States Army Medical Command, 28 February 2001, *Operations Management Bulletin No. 2-01, Hazardous Material Policies and Procedures*.
Healthsafetyinfo.com, "Glutaraldehyde or non-glutaraldehyde products? What's best for disinfection and your employees."
(available at http://www.healthsafetyinfo.com/articles/glutaraldehyde1.html)

North Carolina Division of Pollution Prevention and Environmental Assistance (DPPEA), *PRO-ACT Factsheet on Silver Recovery from Photographic and Imaging Wastes.*
(available at http://www.p2pays.org/ref/05/04619.htm)

Pacific Northwest X-Ray Inc. (http://www.pnwx.com)

Steris Corporation Web Site for SYSTEM 1 Sterile Processing System
(http://www.steris.com/products/ViewProductPage.cfm?ProductID=29)

U.S. Environmental Protection Agency Region 9 Pollution Prevention Program, U.S. Environmental Best Practices for Health Care Facilities, November 2002, "Replacing Ethylene Oxide and Glutaraldehyde."
(available at http://www.ciwmb.ca.gov/wpie/Healthcare/EPAEtOGlut.pdf)

U.S. Environmental Protection Agency Lists of Substitutes for Ozone-Depleting Substances
(available at http://www.epa.gov/ozone/snap/lists/index.html)

U.S. Food and Drug Administration, Center for Devices and Radiological Health, FDA-Cleared Sterilants and High Level Disinfectants with General Claims for Processing Reusable Medical and Dental Devices,March 2003.
(available at http://www.fda.gov/cdrh/ode/germlab.html)

FDA, Center for Devices and Radiological Health, Device Program Area, Reuse of Single Use Devices.
(available at http://www.fda.gov/cdrh/reuse/index.html)

FDA, Center for Devices and Radiological Health, Appendix A: List of SUDs Known To Be Reprocessed (from: Enforcement Priorities for Single-Use Devices Reprocessed by Third Parties and Hospitals - August 14, 2000) (List Updated 11/13/2000)
(available at http://www.fda.gov/cdrh/reuse/1168a.pdf)

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APPENDIX B - ABBREVIATIONS

AAPPSO – Army Acquisition Pollution Prevention Support Office

ACR – American College of Radiology

AC&R – Air Conditioning and Refrigeration

amp – ampere

AP – Affirmative Procurement

AR – Army Regulation

ASA (ALT) ESO – Assistant Secretary of the Army for Acquisition, Logistics and Technology Environmental Support Office

AUL – Authorized Use List

CAA – Clean Air Act

CDRH – Center for Devices and Radiological Health

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

CFC – chlorofluorocarbon

CFR – Code of Federal Regulations

cm – centimeter

CPG – Comprehensive Procurement Guidelines

CR – Computed Radiography

DA – Department of the Army

DLA – Defense Logistics Agency

DOD – Department of Defense

DRMO – Defense Reutilization and Marketing Office

DRMS – Defense Reutilization and Marketing Service

DSCR – Defense Supply Center Richmond

EO – Executive Order

EPA – United States Environmental Protection Agency

EPCRA – Emergency Planning & Community Right-to-Know Act

EPP – Environmentally Preferable Buying Practices

ER – electrolytic recovery

EtO – ethylene oxide

°F – degree Fahrenheit

FAR – Federal Acquisition Regulation

FDA – United States Food and Drug Administration

FFDM – Full Field Digital Mammography

FY – fiscal year

gal – gallon

GEMS – General Electric Medical Systems

GSA – General Services Administration

HAZMAT – hazardous material

HAZMINCEN – Hazardous Material Minimization Center

HBFC – hydrobromofluorocarbon

HCFC – hydrochlorofluorocarbon

hr – hour

HW – hazardous waste

Hz – hertz

IX – ion exchange

kW – kilowatt

L – liter

lb – pound

LDR – land disposal restriction

mg – milligram

MRC – metallic replacement cell

MSDS – Material Safety Data Sheets

MSW – municipal solid waste

MTF – medical treatment facility

ODC – ozone depleting chemical

ODP – ozone depleting potential

ODS – ozone depleting substance

O&M – operation and management

P2 – pollution prevention

ppb – parts per billion

ppm – parts per million

QC – quality control

RCRA – Resource Conservation and Recovery Act

RMW – regulated medical waste

SUD – single use device

TCLP – toxicity characteristic leaching procedure

USACHPPM – United States Army Center for Health Promotion and Preventive Medicine

UV – ultraviolet

V – volt

wk – week

yr – year